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EDITED BY J. McKEEN CATTELL

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THE SCIENTIFIC MONTHLY

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"LOUIS AGASSIZ, TEACHER"[1]

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I

In a recent review, Dr. Edwin E. Slosson suggested that some graduate student should take as his thesis "The genealogical tree of great American scientists" or "The contagion of ideas," using as an example the far-reaching influence of Agassiz. But what of the forces that moulded Agassiz? In his case the contagion of ideas goes directly back to the great embryologist of Munich, Ignaz von Döllinger. To Cuvier and Humboldt, also, he gratefully acknowledged his profound indebtedness, but he once said to me:

> I lived for three years under Dr. Döllinger's roof, and my scientific training goes back to him and to him alone. It was Döllinger who first taught me to trace the development of animals.

Of his own lodging in the scientist's home at the University of Munich he spoke as follows in one of his addresses:

> It was bedroom, library, drawingroom, study, fencing-room all in one; students and professors used to call it "The Little Academy."

In that "little academy" some of the most important discoveries of the time were made. There were first discussed the distribution of Baltic fishes, the anatomy of the lamprey and, most important (by Schimper and Braun), the law of phyllotaxy, "the marvellous rhythmical arrangement of the leaves of plants," as Agassiz described it.

In Europe, Agassiz was a student and investigator rather than a teacher. Yet, in his brief professorship at Neufchâtel, he showed the same tireless energy which built up the Museum of Comparative Zoology at Cambridge. With boundless enthusiasm he gathered

[1] Designation used by Agassiz, in his will. This essay was read at the fiftieth anniversary of the school at Penikese, August 13, 1923.

about him a houseful of cooperating students, a hive of workers, sharing with them his scanty income and maintaining a publishing house with a steady output of useful works, the largest and most pretentious being his "Nomenclator Zoologicus." His monumental contributions came later, however. They deal on the one hand with the fossil fishes, on the other with the glacial system of the Alps and of Northern Europe.

Leaving Neufchâtel, he went to study at the Jardin des Plantes in Paris. Here he came under the influence of Cuvier, the great master of comparative anatomy, whose mission was to make the classification of animals not an arbitrary scheme of convenience but a reflex of their structure. Before Cuvier, taxonomy had little meaning. Each different kind, very uncritically described, was called a species and flung into a convenient genus, as into a pigeon-hole; that these adjustments correspond to essential realities of structure and of origin was scarcely apprehended. It was left to Darwin to lead systematists to realize that a permanent scheme is a map of relationships and that systematic zoology and botany rest finally on our knowledge or conception of genetic origins and connections. In large degree, Agassiz's attitude was a continuation of that of Cuvier, whose mantle was said to have fallen on him.

In the Jardin des Plantes, according to Theodore Lyman, one of his early students:

> He worked for years, never knowing the value of silver except as it served to get his meals at some café of the students, or when very fortunate, to buy some scientific book second-hand from the open air stalls near the Institute.
>
> His small handwriting, which seemed unnatural in so broad and impulsive a character, was a result of early necessity. On the backs of old letters and on odd scraps of paper he copied as closely as possible many volumes which he needed but could not buy.
>
> Those little low rooms, five in all, in the old building at Paris, propped up at one end with timbers—they should be the mecca of scientific devotees! Perhaps every great zoologist of the past hundred years has sat in them and discussed the problems which are always inviting solution and are never solved. Cuvier, Humboldt, Johannes Müller, Valenciennes, Von Baer—they have all gone except the last, who lingers to remind us of the giants that once were.
>
> Everywhere in these galleries and laboratories, it is the same. You are surrounded by the traditions of science. The spirits of great naturalists still haunt the corridors and speak through the specimens their hands have set in order.

It was in Paris, also, that Agassiz first met Humboldt. In an address at Boston he graciously describes his relation to the author of "Cosmos":

> Humboldt's sympathy for all young students of nature was one of the noblest traits of his long life. It may truly be said that towards the close of his career there was hardly one prominent or aspiring young man in the world

who was not under some obligation to him. His sympathy touched not only the work of those in whom he was interested but extended also to their material welfare and embarrassments.

At that period (1831) I was twenty-four and he, sixty-two. I had recently taken my degree of Doctor of Medicine and was struggling not only for a scientific position but for means of existence also. He gave me permission to come as often as I pleased to his room, opening to me freely the inestimable advantages which intercourse with such a man gave a young investigator like myself. But he did far more than this. Occupied and surrounded as he was, he sought me out in my own lodging. The first visit he paid me at my narrow quarters in the Quartier Latin was characteristic of the man. After a cordial greeting he walked straight to what was then my library—a small bookshelf containing a few classics, the meanest editions bought for a trifle along the Quays, some works on philosophy and physics, his own views of nature, Aristotle's "Zoology," Linnaeus's "Systema Naturae," Cuvier's "Règne Animal," and quite a number of manuscript quartos, copies which, with the assistance of my brother, I had made of works I was too poor to buy, though they cost but a few francs a volume.

Most conspicuous of all were twelve of the new German cyclopedia presented to me by the publisher. I shall never forget, after his look of mingled interest and surprise at my little collection, his half-sarcastic question as he pounced on the great encyclopedia, "Was machen Sie denn mit dieser Eselsbrücke"? ("What are you doing with this Ass's Bridge"?)

It was, no doubt, apparent to him that I was not over familiar with the good things of this world, for I shortly received an invitation to meet him at six o'clock at the Palais Royal, whence he led me into one of those restaurants the tempting windows of which I had occasionally passed by.

When we were seated, he half laughingly, half inquiringly, asked me whether I would order the dinner. I declined the invitation, saying that we should fare better if he would take the trouble. And for three hours which passed like a dream I had him all to myself. How he examined me and how much I learned in that short time!

How to work, what to do, what to avoid, how to live, how to distribute my time, what methods of study to pursue—these were the things of which he talked to me on that delightful evening.

It was not enough for him to cheer and stimulate the student; he cared also to give a rare indulgence to a young man who could allow himself few luxuries.

In 1846, at the age of 39, Agassiz left Paris for America. "He came in a spirit of adventure and curiosity. He stayed because he loved a country where he could think and act as he pleased and where his ceaseless activity would be considered a high quality—a land where nature was rich, but tools and workmen few and traditions none." "It was the act of a man bold, restless and original. He was not spurred by failure, for his reputation had been already made" by his monographs on the glaciers and the fossil fishes, and he had been offered the directorship of the national museum at the Jardin des Plantes, than which no higher distinction could be granted by France.

His entrance into the faculty of Harvard College marked the

beginning of a new era in American education. He has been called our first university builder, because of his unprecedented emphasis on advanced and original work as factors in mental training. He laid great stress on the direct study of nature; to know something well is "the backbone of education." Science is built on induction; it is human experience tested and set in order. Hence arose his zeal for research, and his enthusiasm "set the heart of the youth in flame." A new force shattered the self-satisfied routine of Harvard!

Some of his associates took alarm at this; it was "making the college lop-sided," they thought. Even broad-minded Emerson suggested that something should be done to check the rush towards natural history. Agassiz retorted that if the college were becoming one-sided, the remedy was not to cut off the vigorous growth, but to stimulate the rest. "I, for one," said he, "would be willing to run a race with any of my colleagues." At one time he declared, as his greatest achievement, that he had "taught men to think." A great teacher always leaves a great mark on every student with whom he comes in contact.

Agassiz was a born optimist; his strength lay largely in his realization of the value of the present moment. He was always ready to help and encourage—"the best friend that student ever had." A contagious enthusiasm surrounded him like an atmosphere. He was a living illustration of Thoreau's aphorism, "There is no hope for you unless the bit of sod under your feet is the sweetest to you in this world—in any world."

During this period he took a vigorous interest in the work of the lower schools. The science they taught was mostly of the routine order, "fourteen weeks" of memorizing in one subject after another. Whenever opportunity arose, he strenuously urged a better method. Speaking before teachers, he always displayed the actual material with which he had to deal. "There will never be good teaching in natural science," he said, "nor in anything else until similar methods are brought into use." He also insisted that a year or two in natural history, the study of things that are, would give the best kind of training for any sort of mental work. Referring to the prescribed "classical course," he used to say, "Harvard is a respectable high school where they teach the dregs of education."

Vivid accounts of his methods of dealing with individual students have been given by Professors Nathaniel S. Shaler, Addison E. Verrill, Burt G. Wilder and especially by Samuel H. Scudder. All these are now brought together in a useful little book, "Louis Agassiz as a Teacher," by Professor Lane Cooper of Cornell.

It was an essential feature of Agassiz's training that he turned men from their chosen groups and gave them for inductive study something of which they knew nothing. They were thus thrown on their own resources to build from the bottom without the burden of bad habits or confusing recollections. Mr. Scudder, a student of butterflies, was set to work for a year on *Haemulon,* a genus of tropical fishes known as "Grunts" or "Roncadors." Shaler, a geologist, was given a series of flounders to compare and dissect, and Morse, an artist, found it his task to know the common clam. Before Hyatt and others were put boxes of mixed fish-bones to be sorted out and arranged. To me, a botanist especially interested in seaweeds, he gave charge of the schooner "Nina Aiken," with which I was to visit the pound nets (or stationary traps) on Martha's Vineyard to gather material for the Museum of Comparative Zoology. Here, then, I made my first acquaintance with marine fishes, finding them in bewildering variety and so full of interest that I have never turned back to the flowers I had formerly studied with eager zest.

In Agassiz's first class of advanced students at Harvard were William James, the philosopher, Joseph Le Conte, the geologist, and David A. Wells, the economist. Subsequent classes, including those present the first summer at Penikese, embraced nearly all the teachers of zoology of what was then the younger generation. No list is now available, but among those personally known to me I recall Nathaniel S. Shaler, Edward S. Morse, Alpheus Hyatt, Jeffries Wyman, Burt G. Wilder, Charles F. Hartt, Addison E. Verrill, Samuel H. Scudder, Frederick W. Putnam, Alpheus H. Packard, Edward A. Birge, Charles D. Walcott, Theodore Lyman, Alexander Agassiz, William Keith Brooks, Charles Sedgwick Minot, Charles O. Whitman, Samuel Garman, Walter Faxon, J. Walter Fewkes, W. O. Crosby, Frank H. Snow, Ernest Ingersoll, Lydia W. Shattuck, Austin C. Apgar and a number of other excellent teachers in normal schools and high schools. Nearly all here enumerated became professors in natural science, using Agassiz's methods, though not one of them adopting all his conclusions.

So far as I know, I am the youngest naturalist now living who ever came under Agassiz's direct teaching, but each of my seniors spread his ideals far and wide. Indeed, I can scarcely recall the name of a single active naturalist in America or in Japan (for Morse taught in the Imperial University of Tokyo, where Mitsukuri, Iijima, Ishikawa and Kishinouye were in his classes) who has not been a pupil of one of Agassiz's students. Thus, the teaching of zoology now rests in the hands of the master's intellectual grandchildren and great-grandchildren. This fact lends point to Slosson's phrase, "the contagion of ideas," and its cognate, the contagion of personality.

II

But in these later days the field of zoological study has broadened and extended into many narrow specialties. Its problems are no longer largely limited to accurate classification on the basis of comparative anatomy nor even embryology nor geologic succession. The theory of evolution has passed far beyond the hypothesis stage, and present activity centers largely about heredity and variation and the physical mechanism on which both depend. No greater advance has been made in biology than the discovery of the physical basis of heredity, the details of which lie beyond a possible guess by either Agassiz or Darwin, demanding a fine technique and powerful microscopes such as neither of them knew. But one unfortunate tendency of this erudite study of what I may call the Mendelian phyllotaxy of life is to turn the beginners from contact and towards theory. A new vocabulary has been introduced—this applicable not to things that are, but to semi-metaphysical conceptions regarding them.

Goethe warned us that "theory is gray, while the eternal tree of life is green." Yet from green to gray, elementary instruction in America is now rapidly turning back. As the old "Fourteen Weeks" series served up the dry bones of obsolete classification, so the new biology brings the beginning student in face of inchoate conceptions, yet to be hardened into science, and in no way inspiring as an outlook on nature. We are, therefore, suffering from the "dry rot of academic biology," so vigorously portrayed by Professor William M. Wheeler. The teacher who roamed the fields with his flock and

> Wandered away and away
>   With Nature the dear old nurse,
> Who sang to him night and day
>   The songs of the Universe

is giving place to the closet and greenhouse investigator who deals with names of conceptions and tendencies as his predecessors did with species and genera.

To the Darwinian theory of evolution by natural selection Agassiz was persistently opposed. Essentially an idealist, he regarded all his own investigations not as studies of animals and plants as such, but as glimpses into the divine plans of which their structures are the expression. "That earthly form is the cover of spirit was to him a truth at once fundamental and self-evident." To his mind, also, divine ideas were especially embodied in animal life, the species being the "thought unit." The marvel of structural affinity—unity of plan—in creatures of widely diverse habits and outward appearance he took to be simply a result of the association

of ideas in the divine mind. To Darwin, on the other hand, those relations illustrated the tie of a common heredity acting under diverse conditions of environment.

But in a manner equally idealistic, it may be urged that if a species or line of heredity be actually changed by the obstacles that modify or split it up in its course, that fact may equally represent a divine thought. The problem before us is to find out the truth. Very few scientific men can conceive of the universe as undirected by some adequate and mighty intelligence, and certainly the evolutionist has a vastly more widened view of divinity than is possible to one to whom "the God of Things That Are" has never been revealed.

Yet Agassiz had no sympathy with the prejudices exploited by weak and foolish men in opposition to Darwin's views. He believed in the absolute freedom of science, and that no authority whatever can answer beforehand the questions we endeavor to solve—an attitude strikingly evidenced by the fact that every one especially trained by him afterward joined the ranks of the evolutionists. For he taught us to think for ourselves, not merely to follow him. Thus, though I accepted his philosophy regarding the origin and permanence of species when I began serious studies in zoology, as my work went on their *impermanence* impressed me more and more strongly. Gradually I found it impossible to believe that the different kinds of animals and plants had been separately created in their present forms. Nevertheless, while I paid tribute to Darwin's marvelous insight, I was finally converted not by his argument, but rather by the special facts unrolling themselves before my own eyes, the rational meaning of which he had plainly indicated. I sometimes said that I went over to the evolutionists with the grace of a cat the boy "leads" by its tail across the carpet!

All of Agassiz's students passed through a similar experience, and most of them came to recognize that in the production of every species at least four elements were involved—these being the resident or internal factors of heredity and variation, and the external or environmental ones of selection and segregation.

Referring to his work on fossil fishes in the early forties, Agassiz once told me, "At that time I was on the verge of anticipating Darwinism, but I found that the highest fishes were those that came first." That is, the sharks, the most primitive in some respects, had the largest brains, the most specialized teeth and muscular system, and judging from the nervous system alone should be regarded as the highest of fishes. But he had fallen into the error of supposing that evolutionary divergence could be measured in terms of progress. Sharks in most regards are primitive as compared with the

welter of bony fishes that followed them. The latter are more distinctly "fish-like," with an enormous variety of specializations, fitting them for their diverse forms of life. As with the sharks their transformations lie outside the line of the supposed ancestry of higher forms. Natural selection while bringing about "progress" in certain lines—or increased specialization through more varied relation to environment—by no means involves universal or even general progress. It leads to varied fitness to actual conditions. Natural selection preserves as ancestors those who run the actual gauntlet of life, and retrogression is as evident a factor in evolution as progress.

Moreover, it is not from the most specialized or fish-like fishes that the higher forms seem to have descended. The supposed ancestors of amphibians and reptiles are the nearly extinct Dipnoans, by no means the highest of fishes, but the most reptilian, and the only group from which higher vertebrates could have sprung.

III

The last and most picturesque of Agassiz's efforts was that which brings you together to-day, and it is a deep disappointment that I can not be present to pay my tribute in person to the greatest teacher I have known.

But in "The Days of a Man" (and elsewhere) I have given my account of Penikese. Its most memorable incident, one that will bear repetition, was recorded by Whittier in a beautiful poem. On the second morning, Agassiz rose from the breakfast table and spoke of his purpose in calling us together. The swallows flew in and out of the building in the soft June air. Some of them grazed his shoulder as he dwelt with intense earnestness on the needs of the people for truer education—needs that could be met by the training and consecration of devoted teachers. This was to him no ordinary school, he said, still less a mere summer's outing, but a missionary work of the highest importance.

A deep religious feeling permeated his whole discourse, for in each natural object he saw "a thought of God" which the student may search out and think over again. But no reporter took down his words, and no one could call back the charm of his manner or the impressiveness of his zeal. At the end he said, with a somewhat foreign phrasing, "I would not have any one to pray *for* me now," adding, when he realized our failure to grasp his meaning, that each would "frame his own prayer in silence."

Even the careless heart was moved,[2]
And the doubting gave assent
With a gesture reverent
To the Master well beloved.

[2] From "The Prayer of Agassiz," by J. G. Whittier.

As thin mists are glorified
By the light they can not hide,
All who gazed upon him saw,
Through its veil of tender awe,

How his face was still uplit
By the old sweet look of it,
Hopeful, trusting, full of cheer
And the love that casts out fear.

Two or three minor incidents described in my notes may be worth recalling. One evening we organized the Agassiz Natural History Society. Agassiz himself attended the first meeting, which in true American fashion was filled with discussions of constitutions and by-laws, constitutional amendments and election of officers. As he sat through our proceedings, he grew more and more uneasy; the business of a Natural History Society, he felt, was natural history, not constitution-making. So he explained how he had helped launch the great French Association for the Advancement of Science without a constitution or elected officers. The members having come together quietly, the youngest of all, without previous agreement, walked up, took the chair and called the meeting to order. "That impudent young rascal was I," said he, laughingly.

Another time Bicknell brought out his new stereopticon, and images of minute life, little jellyfishes, crustaceans and sea-worms were thrown upon the screen. The shapes and antics of some of these, immensely magnified, were very funny. Wishing to point out a notable feature—that is, the circulation of the blood corpuscles in the veins of a tadpole's tail—Agassiz approached the screen and in so doing stepped into the beam of light, when instantly his silhouette was cast upon the broad white surface with startling effect.

"It seemed to shadow forth," said Garman, "that distant day when future students of nature, looking back, shall see the figure of Louis Agassiz standing alone and majestic against an unoccupied background of American science."

One morning I heard Agassiz calling: "Mr. Jordan, Mr. Jordan, will you come and look at this!" It was a patch of grass thickly studded with mushrooms which had developed over night. "How did this happen?" he asked.

Looking about I found a place to the windward where the turf had been dug up. Apparently, therefore, loose dirt blown by the wind had borne and deposited many mushroom spores amid the grass. This conclusion we verified by discovering another excavation with its corresponding patch of fungi. I then explored the whole island, finding a mere half-dozen scattered individuals. It

thus seemed certain that spores could escape in abundance only by a fresh breaking of the turf.

The last letter I received from Agassiz (November, 1873) was an appeal to study the development of the eggs of the Gar Pike (*Lepidosteus*) abundant in rivers of Wisconsin, where I was teaching. *Lepidosteus* was of particular interest to him; at Penikese he had told me with zest how Cuvier showed him a precious specimen of this creature of reptilian affinity strongly resembling the extinct bony-scaled ganoids on which he himself was working. Moved by the interesting possibilities, Cuvier then gave him two scales for microscopic examination, and to Agassiz's delight he found these—diamond-shaped and enamelled—to be formed exactly like those of some of his fossils.

Agassiz's talks at Penikese covered a wide range of subjects—the European naturalists, the history of geology, the glacial system, methods of teaching. From my notebooks I have culled a few of his sayings, mostly unpublished, just as I wrote them down:

Never be afraid to say "I do not know."

Strive to interpret what really exists.

I feel more vexed at impropriety in a scientific laboratory than in a church. The study of nature is intercourse with the Highest Mind. You should never trifle with Nature. At the lowest, her works are the works of the highest powers, the highest something in the universe in whatever way we look at it.

I have been criticised in Europe as one who derives his scientific ideas from the church. I have been regarded in America as an infidel, because I will not be dictated to. I will not suffer my church-going friends to pat me on the head.

Have with traditional belief and dogmatic science nothing to do. Scrape it off. If we are weak let us humbly fall back for support on tradition and belief. If we are strong let us see what there is outside of these.

Never try to teach what you yourself do not know, and know well. If your school board insists on your teaching anything and everything, decline firmly to do it. It is an imposition alike on pupils and teacher to teach that which he does not know. Those teachers who are strong enough should squarely refuse to do such work. This much-needed reform is already beginning in our colleges, and I hope it will continue. It is a relic of medieval times, this idea of "professing" everything. When teachers begin to decline work which they can not do well, improvements begin to come in. If one will be a successful teacher, he must firmly refuse work which he can not do successfully.

It is a false idea to suppose that everybody is competent to learn or to teach everything. Would our great artists have succeeded equally well in Greek or calculus? A smattering of everything is worth little. It is a fallacy to suppose that an encyclopedic knowledge is desirable. The mind is made strong, not through much learning, but by the thorough possession of something.

Lay aside all conceit. Learn to read the book of nature for yourself. Those who have succeeded best have followed for years some slim thread which has once in a while broadened out and disclosed some treasure worth a life-long search.

A man can not be a professor of zoology on one day, and of chemistry on the next, and do good work in both. As in a concert all are musicians—one plays one instrument, and one another, but none all in perfection.

You can not do without one specialty; you must have some base-line to measure the work and attainments of others. For a general view of the subject, study the history of the sciences. Broad knowledge of all nature has been the possession of no naturalist except Humboldt, and general relations constituted his specialty.

Select such subjects that your pupils can not walk without seeing them. Train your pupils to be observers, and have them provided with the specimens about which you speak. If you can find nothing better, take a house-fly or a cricket, and let each hold a specimen and examine it as you talk.

In 1847 I gave an address at Newton, Massachusetts, before a Teachers' Institute conducted by Horace Mann. My subject was grasshoppers. I passed around a large jar of these insects, and made every teacher take one and hold it while I was speaking. If any one dropped the insect, I stopped till he picked it up. This was at that time a great innovation and excited much laughter and derision. There can be no true progress in the teaching of natural science until such methods become general.

There is no part of the country where, in the summer, you can not get a sufficient supply of the best specimens. Take your text from the brooks, not from the book-sellers. It is better to have a few forms well known than to teach a little about many hundred species. Better a dozen specimens thoroughly studied as the result of the first year's work than to have two thousand dollars' worth of shells and corals bought from a curiosity shop. The dozen animals would be your own.

Teach your pupils to bring in their specimens themselves, and above all teach them how to handle them. The earlier this training is begun the better. There is not one person in fifty who knows how to handle a valuable specimen without injuring it, and not one in ten who will submit to being taught.

Talk about your specimens and try to make the pupils observe the most striking and telling features. When you collect a specimen, be sure and find out what it is, or if you have not the means at hand, take such notes as will help you to find its name when you have opportunity. Better let a specimen go without a name than to give it a wrong one.

There should be a little museum in every school-room; a half-dozen Radiates, a few shells, a hundred insects and a few fish, reptiles, birds and mammals would be sufficient to teach well. De Candolle, the great botanist, once said that he could teach all he knew about botany with a dozen plants.

If you study nature in books, when you go out-of-doors you can not find her.

The book of nature is always open. All that I can write or say shall be to make them study that book and not pin their faith to any other.

This is the charm of study from Nature herself; she brings us back to absolute truth whenever we wander.

THE WORLD AND ART OF THE ANCIENT CAVE MEN

By Professor HAROLD O. WHITNALL

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THE world is much interested in the wondrous works of art that have been found in the tomb of Egypt's Pharaoh, Tut-ankh-Amen. Millions have read of the lavishness of the display, and its superb artistry has sent thrills through all lovers of the beautiful.

Such a discovery reacts in many ways on many minds. Some think of it only in pounds sterling or the American dollar. Those of a more artistic temperament or of finer sensibilities revel in the beauty of design and marvelous workmanship. The very antiquity of the tomb and its contents appeals most strongly to some, while others are thrown into a philosophical mood and exclaim with the preacher: "Vanity of vanities, all is vanity."

In the light of modern science Tut-ankh-Amen is but a man of yesterday and the art that surrounded him is one that had a very remote background. Man's antiquity is great, far exceeding the views that were held fifty years ago. Then, the problem of the occupancy of the earth by man was debated in thousands of years, while now it is a question of how many hundreds of thousands of years have passed since his advent.

The very ancient race that is our especial concern, a race possessing an unusually well-developed artistic sense, is known as the Crô-Magnon. It takes its name from a skeleton discovered many years ago in a cave in the valley of the Vézère, a tributary of the Dordogne in France. The descriptive term "very ancient" must not lead us to expect that our kith to be described are representatives of earliest man. It is generally agreed that Crô-Magnon tribes lived in Europe in late Paleolithic time, a period estimated to be from 20,000 to 25,000 years ago, three or four times as ancient as the Egyptians or Babylonians of the dawn of history, but several hundreds of thousands of years nearer to us than our primordial ancestors.

Europe was inhabited long before the coming of the Crô-Magnons by several different human races. Indeed, if the estimates of geologists are correct and the geological positions of these pre-Crô-Magnon remains have been rightly determined, man lived in Europe nearly a half million years ago. Hence the Crô-Magnons were comparatively recent migrants to the soil of Europe.

They were the artists *par excellence* of prehistoric time. Their mural paintings and parietal engravings that embellish scores of cavern walls in southwestern Europe are among the wonders of the world. To understand this art and fully to appreciate it, it is necessary to describe Crô-Magnon men, their habits, habitats and the scenes on which they looked.

Their physical type was superb. They were a tall race, standing well over six feet. The aboriginal races of Europe must have considered these immigrants as giants, even as the children of Israel thought of the sons of Anak. Besides their height, their broad shoulders, deep chests, slender, long and muscular limbs, with noble head well balanced on stocky but not bull-like neck, gave them a most stately bearing. The face approached the Caucasian type, although the projecting upper teeth and the prominent cheek bones spoiled what we would call "their good looks." Their physique, their cranial capacity and cast of countenance as restored through a study of their skeletal remains, compel us to regard them as one of the finest types that the world has ever seen. This estimate is augmented by the art they have left. Because of its great antiquity and the difficulties that environed the artists in its execution Crô-Magnon art is one of the most marvelous manifestations of man's artistic sense that has been found.

Thanks to the indefatigable labors of a small group of European scientists, who have slowly and carefully gathered scattered bits of evidence of the times in which Crô-Magnon man lived and who have patiently pieced together these bits of testimony, it is possible to build from them a mosaic, which, although containing gaps and breaks, here and there, is in the main a true picture of those remote days.

The Europe of that time presented a very different aspect from that of to-day. When the Crô-Magnon artists were drawing and painting pictures on stony walls in the gloomy recesses of caverns and Crô-Magnon hunters were stalking their quarry, Scandinavia was covered with an ice sheet which extended southward over the Baltic depression and rested its icy feet on the lowlands of northern Europe; the Alpine glaciers were much more extended than now and, from the high Pyrenees, ice-tongues crept slowly down towards the plains. In southern France, which seems to have been the center of Crô-Magnon culture, the air was chilled by the icy breath of the frozen north, while the less extensive ice areas to the east and south contributed no small amount of cold winds. The effect of such a bleak climate, with seasons of nipping chills, compelled men to leave open camps and to take refuge in the shelter of overhanging ledges or in the more protected caverns. Thus it was that Crô-

Magnon man passed a great part of his existence as a troglodyte.

Because of certain popular fallacies that concern the life of ancient man the temptation comes to parenthesize a paragraph and state that caves were not the first dwelling-places of mankind. Earliest men were children of the open spaces, dwelling along river banks or in park-lands, and it was only when compelled by adverse climates that they entered caves which afforded immunity from the raw winds and freezing cold. Again there is a current misconception that the men living during the glacial periods were dwellers near or even on the ice itself. Kipling is guilty of this fallacy when he writes of Ung, the Maker of Pictures:

> Straight on that glittering ice-field, by the caves of the lost Dordogne,
> Ung, a maker of pictures, fell to his scribbling on bone.

Now the fact of the matter is that the inhabitants of the Dordogne caves were 600 miles from the great Scandinavian ice-sheet; 200 miles from the Alpine cap, and at least 150 miles north of the small glaciers that lay in the higher valleys of the Pyrenees. It is probable that the bulk of the population had never seen ice-fields, although it is quite possible that legends were common of the great hard white ocean that lay on the confines of their world. The effect of the extensive frozen solitudes was keenly felt, but the cause was unseen and unknown.

Finally, it must be understood that the climates of the region in which these ancient artists lived were not uniform. Throughout the thousands of years of Crô-Magnon domination not only seasonable climates prevailed, but secular changes were also in process. The great climatic pendulum swung back and forth through the millenniums not with a steady movement but with periodic inequality. Furthermore, the arc through which it passed was short; never did the mean temperature rise to the present warmth of the region nor did it sink to arctic cold.

The fluctuations, however, were sufficient to permit at least three types of geographical features with their accompanying animal life. It is of importance to understand these climatic stages, for they, of course, dictated the fauna of those times. The knowledge of the mammalian life that was associated with Crô-Magnon man throws much light upon his own life and habits. Primarily, he was a hunter and his very existence depended upon the chase. Again, a knowledge of the animals gives testimony as to the vegetation and its distribution. Thus acquaintance with the climate, animals and plants enables one to have a vivid picture of those far-off days.

The culmination of Crô-Magnon art appears in the engravings

and monochromes and polychromes which were painted during the closing stages of the Crô-Magnon period. For thousands of years previously these savages had been engravers and sculptors both in the round and in bas-relief work; but most of their work had been done on portable objects as bone, ivory, horn and pieces of stone. It seems, therefore, that painting, which many art critics maintain is the apogee of all art, developed as a natural sequence in a race that was peculiarly sensitive to the artistic impulse. The high tide of art came in the final cultural phase of the race. This stage is known among prehistoric archeologists as the Magdalenian, so called from the type station, the cave of La Madeleine, on the Vézère. It is in the parietal engraving and paintings of these times that our chief interest lies.

This Magdalenian phase had three types of climate. Ushered in by a severe, cold, moist climate, tundra conditions were widespread over Europe, and the reindeer, mammoth, woolly rhinoceros and musk-ox grazed and browsed over a wide territory. So intense was the cold in southwestern Europe that even the musk-ox, that shaggy beast of the snow-fields, wandered as far south as the Pyrenees.

The climatic pendulum swung again. It still remained cold, but less moisture was in the air. Strong dry winds swept over the land, bringing clouds of dust which settled as a great blanket and remains even now as a geologic reminder of those great dust blizzards. This semi-aridity considerably diminished and changed the food supply of the animals. The dwarfed but widespread vegetation of the tundra wastes could not maintain its foothold generally; only along the margins of lakes and rivers and depressed swampy places did it persist. Great areas took on the character of cold steppe-lands. On such plains and hills the vegetation of spring and early summer soon became parched and offered but a precarious pasturage to grazing animals. The only animals that could survive in such regions were those that could exist on scant vegetation and that were fleet of foot. Representatives of such animals were the saiga antelope and a horse closely allied to the wild desert horse of Asia.

These and smaller mammals became quite abundant in western Europe during this period, and their bones are mingled with those of the tundra animals on many a charred hearthstone of Magdalenian time. For, although the semi-aridity must have driven out a large number of the tundra forms, a great proportion of them found sustenance along the grassy margins of the waterways and other favored spots.

The last stage of Magdalenian times was characterized by a moist and continually moderating climate. The steppe fauna dis-

appeared early and was followed by the gradual withdrawal, towards the ever-retreating ice front, of the tundra animals. Slowly, great forests, park-lands and meadows developed over Europe, and with them came the life of woodlands and succulent meadows. Typical of the meadow animals were the bison and wild cattle, while the forests became stocked with red-deer, stag, moose, wild boars and other denizens of the woods.

Such were the types of climate during the centuries in which the Magdalenian men of the Crô-Magnon race made their pictures on the walls of dark caverns. As we try to reconstruct the scenes on which the eyes of these ancient people rested we must be careful not to let the term tundra create an image of the illimitable leagues of the moss- and lichen-covered plains of northern Canada. Nor should the name steppe merely call to mind the great monotonous plains of southeastern Europe or northern Asia. For both these type regions suggest thousands of leagues of level stretches, broken only by gentle ridges rolled on one another in monotonous torpor.

Tundra and steppe conditions were present but on a much smaller scale. Southwestern Europe was, as regards the general features of the topography, the same then as now. The Garonne and the Dordogne, of France, and the Tagus, Ebro and Douro, of Spain, flowed as they do now through rocky gorges in their upper reaches and meandered across wider valleys as they approached the sea. Minor changes have of course come; most of the streams have deepened their valleys somewhat; many of the rocky ridges have been softened, and the hand of modern man has here and there produced considerable change. On the whole the contour of the land is not so different that it could not be recognized by those ancient inhabitants could they but see it. Climate does not always produce profound changes of the form of the earth but clothes it in varied costumes.

Nor was the sequence of the seasons different. Spring, summer, autumn and winter came to those ancient hunters as they come to the present peasants of the valleys and hills. In summer it was a land of sound, birds sang, insects hummed and the croaks of the amphibians rose from the marshes. Streams babbled and splashed their way to the sea and the summer winds produced the world-old whispers of the leaves. In winter it was a land of silence, broken only by booms from ice cracks, the crunching herds of winter animals on the crusty snow and the weird cries of winter birds.

In such a familiar world lived our ancient race, familiar and yet not altogether so, for of his animal associates few species have survived. Types of many of them still persist, but some have vanished from the earth forever. Many of them were vital to the needs

of these men, for they supplied them food and clothes and bone implements. They were also the models of the artists, for the Crô-Magnon engraving and painting was confined almost exclusively to animal types.

We have glimpsed his hunting grounds; let us look at his habitations. Magdalenian man roamed over a large territory. So far, evidence of his presence has been found in Spain, France, Belgium, Germany, Switzerland, pre-war Austria and perhaps England. Although no proven Magdalenian stations have been found in England, there is no good reason why they should not be discovered there, for there was a land communication between France and England at the beginning of Magdalenian time. Whether this persisted throughout the entire time phase is not yet proven.

France was the center of Crô-Magnon population, and it was there and in the adjoining Pyrenees of Spain that his art rose to its highest expression. There are two regions, both in southern France, that were apparently highly favorable to the life of the Crô-Magnon Magdalenians. One was not far from the present Spanish frontier, along the head waters of the Garonne and its tributaries; the other was in Dordogne, along, or near, the valley of the Vézère, near its point of juncture with the Dordogne in a locality which takes its name from Les Eyzies. In the Les Eyzies district at least twenty caves and shelters have been found that contain Paleolithic remains, and in many of these mural paintings and parietal engraving occur.

There were many things that caused the Dordogne and adjoining regions to be favored by these ancient hunting tribes. Perhaps the most potent influence was the climate. It was not an ideal one, that is, not one that primitive man would have deliberately chosen; yet its very coldness was, had he but realized it, the spur that drove him on to better things. "Progress, adjust and adapt, or be destroyed" was the challenge that the cold long winters and chilling blasts brought to the European savage. He met that challenge and moved onward mentally and spiritually. It has always been thus. Man has met the bludgeon blows and rapier thrusts of nature and in so doing has learned to a great extent how to parry and overcome. He is "nature's insurgent son"; it is only where nature is kind that man remains nature's child.

Another feature of the environment that gave strength and wellbeing to the Dordogne tribes was the varied and abundant game, especially the large quadrupeds whose pictures adorn so many cavern walls. To those meat-eating savages these animals were the "staff of life"; without them they would have perished or else eked out a miserable existence from wild fruit, roots and an occasional

meal of fish. Then again the use of the animals' skins played a large part in their lives, enabling them to withstand the rigors of long and often severe winters.

But even with the abundant food supply and its important by-product of clothing it is difficult to imagine the population existing without shelters to shield them from the icy blasts of winter. They might have struggled through the cold seasons by living in skin tents as the Indians of northern Canada do, but such insufficient shelter would have lowered the vitality of the race and impoverished their mentality to such an extent that they would have degenerated, as the Terra del Fuegians have, to a state where life is only food and sleep and the instinctive rearing of children. This degeneracy they escaped because the geological forces of the past had grooved the hills with rock shelters and honeycombed the cliffs and rocky hillsides with caves. Thus, all things considered, it was a congenial region, furnishing plenty of food and clothing and homes that answered to their every need.

In all the Dordogne region the lower valley of the Vézère was best fitted for the dwelling-place of these savage troglodytes. In this region the Vézère flows through an old incised meander carved throughout the ages in limestone rocks. It is an extremely picturesque region. The river winds in long stately loops through a valley in which lie level and fertile meadows. On each side rise the limestone cliffs, sometimes abruptly for many feet. At other places their sheer sides are notched with broad ledges. Here and there the ledges extend inward and are overhung with massive rocks. These lateral flutings into the sides of the cliffs are the rock shelters, or, as the French called them, the *abris*. These shelters may be only overhanging cliffs, or they may extend inward and form grottoes. Occasionally they may be entrances to extensive caves. From the evidence at hand it seems probable that the shelters and the grottoes were the real homes and that the caves were only entered by the artist guild.

The cliffs are very striking features of the landscape, for their steep sides prevent the growth of all but the scantiest vegetation. Here and there a ledge, on which the talus material lies thick, offers a foothold for clumps of trees. The summits of the cliffs are well wooded. The picture that is presented in the summer time is most charming. The level valley with its fields of varied green tints, with the clear, strong, yet quiet river forms the foreground. From the outer bends in the river rise the light-colored rock walls, their barren sides colored here and there with hues of jade and emerald, their summits clothed with deep green woods.

Let the fairy godmother of time wave her wand over the region

and bring back scenes long gone by. Tundra conditions prevail. The general topography is the same, the river flats are ablaze with brilliant flowers growing in the scrubby vegetation of the hot but short summer. Herds of reindeer dot the plain. At times an ibex or chamois, driven from alpine solitudes by the all-embracing ice-sheet, walks with sure step along the rocky ledges. A half dozen stalwart savages climb fleet-footed up to a shelter under an overhanging rock and with much gesticulation tell the group that receives them of herds of mammoth they have seen to the west. The hunters arm themselves with crude stone weapons and arrows and depart to capture, by direct attack or by pitfall, one of those great quadrupeds. Their hunt is highly successful, for they not only kill a mammoth but drive a woolly rhinoceros into mucky ground lying along the margin of the river and kill it while it struggles helplessly.

The magic wand of time is waved again. This time steppe conditions occur. It is late summer; the valley is bare of grass save along the river margins. There, nervously grazing, raising their heads constantly to "get the wind," were small groups of horses and slim-limbed antelopes. The Crô-Magnons look down upon them from their rocky ledges and whisper plans of surprising them, for these were the most difficult animals to hunt that the tribes knew.

Once more the wand describes a circle. Again it is summer, and the landscape presents almost the same view as now. The river flats are green and the cliffs shine white in the warm sunlight. The bare rocks are ribboned and crowned with green. Far down the valley the meadow is broken by woodlands. In the forests of the plains and hills live the red-deer, moose, stag and wild boar. At night the sleepers on the cliffs are awakened by the howl of wolves, and cave-bears blundering on the ledge above loose a shower of stones which rattle down the cliffs. The Magdalenians arise from their skin-blankets and heap on some more firewood, for they know that the "red-god" is feared by these wild prowlers of the night.

Since 1828 when Tournal demonstrated the association of man with extinct animals of the glacial period in the grotto of Bize (France), dwelling-places of the men of the old stone age have been found by the hundreds. In many of them lived at one time or another men of the Crô-Magnon race. It must not be presumed, however, that every home was decorated by the tribal artists. These men of Magdalenian days were predominantly hunters and art was but the avocation of a few. Indeed, it appears that their art galleries and studios were things apart from their homes, for much of the best work was done in the deeper recesses of the caverns in places that were far removed from the family hearths.

Whistler, in his "Ten o'clock," describes the first artist as:

"This man who took no joy in the ways of his brethren—who cared not for conquest and fretted in the field—this deviser of the beautiful who perceived in nature about him curious curvings, as faces seen in the fire—this dreamer apart, was the first artist."

Kipling voices the same sentiment when he makes the father of Ung say to his artist son:

"Thou hast not toiled at the fishing when the sodden trammels freeze,
Nor worked the war boats outward, through the rush of the rock-staked seas,
Yet they bring thee fish and plunder—full meal and an easy bed—
And all for the sake of thy pictures." And Ung held down his head.

"Thou hast not stood to the aurochs when the red snow reeks of the fight;
Men have no time at the houghing to count his curls aright:
And the heart of the hairy mammoth thou sayest they do not see,
Yet they save it whole from the beaches and broil the best for thee."

No one who has ever seen the animated and spirited figures that adorn so many cavern walls can believe that the men that drew them were anemic "stay-at-homes" and obtained their experience and feeling from the mere sight of the carcass which their bolder brothers had dragged into the shelter to be cut up, skinned and roasted, nor even that their knowledge was derived from a hunt in which they had no part. Indeed, quite the contrary impression is gained. The hands that drew the animals must have often struck the fatal blow, and the minds that created the pictures might well be the same ones that had many times skilfully trailed the quarry and driven it into hidden pits or miry ground.

From the many caverns that contain engravings and pictures there are two especially well known which will serve to introduce the art of the cave-men. One is the cavern of Font de Gaume in the district of Les Eyzies, the other the cave of Altamira, in the Cantabrian Pyrenees of northern Spain. Inasmuch as it was at the latter place that the discovery of paleolithic paintings was first made it will be considered first.

The cave of Altamira is not far from the city of Santander. The discovery of the cave and its contents was due to two very innocent parties, a dog and a child. Long ago the entrance to the cave had been sealed by a landslip and its existence was unknown until a hunter and his dog passed that way. The dog, in running a fox to ground, widened the burrow and showed the hunter that it led to a cave. Years afterward, a Spaniard, Marcelino de Sautuola, who owned the estate in which the cave was situated, became interested in the crude man-made flints which he had found in the cavern débris.

One day, accompanied by his little daughter, he was seeking for

implements in a portion of the cave where the limestone roof came within a few feet of the floor. The child, able to stand upright without bumping her head, wandered aimlessly about while her father searched the cave earth for specimens. Suddenly she cried out: "The bulls! The bulls!" Her father looked to where her finger pointed and saw a marvelous sight. Painted and engraved on the ceiling was a conglomeration of animals, deer, horses, wild boars and bison, the latter greatly predominating.

The world gasped when Lord Carnarvon entered the inner chamber of Tut-ankh-Amen's tomb and gazed on objects which no human eye had looked upon for nearly 4,000 years. But to this little daughter of Spain was given the privilege of looking at an art that had been concealed for four times that stretch of years.

Cartailhac and Breuil, the eminent European archeologists, say that these pictures "place the old painters of the glyptic ages far above the animal painters of all the civilizations of the classic East and Greece." No matter how much art critics may quarrel over this statement, the fact remains that the ceiling of the Altamira must always be a shrine to artists who are modest enough to believe that all art did not originate with them.

Looking at the ceiling as a whole several salient features appear. There is no attempt made at grouping. It can not be called a picture; it is rather a collection of pictures painted on the same rock canvas. The figures are not all completed. Here and there appear head profiles and body contours which were started but never finished. It is like a sketch book of an erratic artist. Another interesting feature is that some engravings have been superimposed on others. Perhaps the most striking thing, aside from the pictures themselves, is the use to which the artists put the uneven surface of the stone roof. The ceiling is studded with protuberances of limestone. The artists cleverly seized upon this feature to enhance the life-like appearance of their representation of the animals. Many of these bosses were oval and presented an excellent background on which to paint bison in a recumbent position.

A brief description of a few of the better executed animals is all that can be given. Of the bison we will select three. One is painted in black. The outline is perfect. The whole figure is covered with black pigment toned in such a way that the effect of relief is excellent. The legs are well drawn and in good proportion. There is even an attempt at shading so as to give the appearance of its shadow being cast on the wall behind it. It stands erect straining on its hind legs. Another bison is shown lying down with its head turned backward, an unusual posture in primitive drawings and one which is difficult to do well. The head and

rump are placed on protruding knobs of stone which accentuates the relief. The color use is not natural, as it is of a brilliant red shade. The chef d'oeuvre of the cavern is a bison over five feet long. It stands erect with head lowered slightly. The coloring is superb. The contours are mostly in black, while the body is filled in with red beautifully toned. Patches of black appear on the body not for shading purposes but to show the different color of the hair. Four shades of color are blended in this animal, and thus it represents the acme of polychrome art. Its perfection is, however, marred by the awkwardness of the fore-limbs. They are in good proportion, but the hoofs are placed sidewise instead of pointing forward.

Of the other animals the best representation is that of a wild boar. This also is five feet in length. It is in rapid motion and is a vivid picture of the woodland boar leaping forward in full flight. The body is painted in light pearl-gray, with the outline sketched brokenly in black. The belly is tinted a delicate flesh color and shadings of black appear on the head and rump. The typical curled tail of the animal is well executed.

There is also a very fine engraving of a stag at Altamira. The lines are very finely drawn and one has to be rather close to it to see it at all. The fore-legs are correctly but rather weakly sketched, and the lines of the hind quarter are not complete. The pose is excellent and the long backward sweep of the antlers magnificent. The horses that are represented are rather incomplete and are not to be compared with the other animals.

The greatest art gallery of Paleolithic time that has yet been found is in the cave of Font-de-Gaume in the district of Les Eyzies in the Dordogne region. It lies well up on the side of a small valley where it joins the valley of the Beune. The limestone cliffs are sheer and bare, and deeply lined joint planes give them the appearance of great blocks. There is a long gallery that extends inward to a distance of nearly 500 feet. The vestibule and the first part of the corridor contain nothing of importance. At a distance of about 75 feet the rock walls begin to close in on one another until but a narrow passage separates them. After the visitor has brushed by the stalagmitic obstructions the picture galleries begin. Two painted bison stand guard at the entrance to the pictured halls. A little farther on is the Grande Galerie des Fresques which contains processions of bison and mammoths. Reindeer are also plentiful. There is one place where two reindeer are drawn facing one another, which may be an accident or may represent a composition. If the latter, it is an unusual feature of Paleolithic art.

A striking characteristic of these frescoes, but one which is quite

common in cave painting, is the superposition of animals on other animals. Take the fresco of mammoths, for example. The first impression is that mammoths alone are represented, but closer inspection shows that the mammoths are drawn over other paintings. In one case a mammoth overlies the drawing of a reindeer which is in turn painted on a bison. In some cases such figures have been blended together so by the fading colors that it is difficult to define each one clearly. The artists that did the work of superposition should not be too severely criticized, for in most cases they drew the more recent pictures on a smaller scale and thus retained the outlines, at least, of the earlier paintings. There has been much speculation as to why this method was pursued. The simplest reason seems the best. There was just so much wall space that was fitted for their art. Hence the late-comers were forced to use the same canvas. True artists as they were they preserved as much of the old art as possible by reducing instead of enlarging their own pictures, an appreciation and courtesy which later artists have not always shown.

About half way between the narrow place previously mentioned and the end of the cavern a lateral gallery runs to the right at right angles to the main corridor. At its end is a little hall which contains nearly a dozen bison in polychrome. This little chamber also contains a most grotesque caricature of the human face.

The cave of Font-de-Gaume contains the greatest variety of animals that has yet been found. Besides those mentioned are the cave bear, a lion, wolf, rhinoceros, wild boar and horses. To these animals must be added the human head, stencils of the human hand and lines that are supposed to represent huts. As was the case in the Altamire cave the bison predominate. It is of great interest to note the appearance here of the mammoth. Their great number means familiarity, which indicates that at one time, at least, the climate was quite sub-arctic.

Another animal which bears testimony to the rigor of the climate is the woolly rhinoceros which is painted in red. This animal is fairly well drawn. The small eye and the characteristic horns are well shown, but the articulation of the limbs is poor. This is especially true of the fore-feet, which are fused together, forming a stump. The artist makes use of a unique method in producing the contour of the body. This is accomplished by sketching parallel lines downward from the back and upward from the belly.

The outlines of the mammoths are all well done, as are also the heads. The bodies, however, leave much to be desired. This is probably due to the difficulty in depicting the long shaggy coat which concealed much of the body contour. This coat, however, is

always indicated by a fringe of fine lines that are drawn on the body a short distance from the belly line and hang down, concealing all but the stumpy appearance of the feet.

The wolf is represented only by the head and neck. It is a striking painting because of its treatment. The background consists of a bright red color on which the outlines were drawn in black. In the light cast by torches the effect is startling. The wolf seems to leap out of a hidden recess. The collar of black fur along its neck is very effective. A bear is very poorly done, but its lack of form is partially atoned for by its spirited position. It is standing on its hind legs in a most realistic attitude. That these artist-hunters knew the horse is attested to by four drawings, none of them remarkable in technique.

Before we leave the cave of Font-de-Gaume mention must be made of the reindeer, a favorite subject with the artists. It is said by some who have made a study of paleolithic painting in many caverns that the two deer that face one another constitute the finest painting that primitive man made of these animals. Both are painted in dull red, which is admirably toned to bring out the contours. The bodies, the antlers and pose are splendid, but the limbs are badly done. With the exception of the one on the right the articulations are most obscure and even in this one the hind limbs are the only ones that show any attempt to indicate the place of juncture with the body.

We have briefly and most inadequately described some of the engravings and drawings of the best known caves of southwestern Europe. Several questions arise to which suggestive answers must be made. What materials did the cave-man use to paint his animals? Why did he seek the innermost recesses of dark and dangerous caverns to ply his art? And finally why did he draw at all?

Fortunately, the caves themselves have yielded the answer to the first question. In them have been found his engraving tools, his colors already mixed, the flat bones he used for his palette, and his canvas. All are there save his brushes.

Without attempting to enumerate the paraphernalia of his art and to tell the localities where each bit of evidence was found, let us in fancy follow the ancient savage while he reproduces in quiet and dimness the animals that he had hunted with boisterous cries and shouts in the full sunlight of his native land.

Two men enter the cave, one the master, the other the neophyte. In their hands they carry stone lamps filled with tallow obtained from the very bones of the animals that are to be painted. In the tallow moss wicks burn, giving off a flickering but not an exceedingly smoky flame. They seek a place where the rock wall is suit-

able for their work. The first step is to wash the stone free from adhering clay and thus prepare the surface. The surface thus cleaned, the painter reaches into his artist's kit-bag of deer skin and takes out a handful of small chipped-stone implements. He selects the coarser one to engrave the profile line on the softer limestone. When the outline has been made he takes a finer flint and draws fine lines where they are needed. Now he is ready for the coloring. Wrapped carefully in another bag are hollow bones filled with ocher, red, yellow and brown. Other bones contain black carbonaceous matter in powdered form, while still others contain white and dusty clay. But the bag is not emptied yet, for there still remains a mass of marrow fat. When this is extracted the master is ready to prepare his colors. On a flat shoulder bone of one of the larger mammals the dry powder from the bone tubes is mixed with the marrow to the desired consistency and shade. Now all is ready for the application. The youthful assistant holds the lamp so that the flickering rays fall full on the rock panel. The master stirs the thick mixture with a stick whose end has been chewed in shreds, or one tipped with feathers or even bristles of the wild-hog, or hair from the shaggy mammoth (no one knows), and with bold strokes begins his work.

The questions why he chose the inner portions of the cavern and the motives that led him to paint at all are closely allied to one another. We will consider them together.

Practically all the finest paintings are of animals that were used for food. The exceptions, such as the bear, lion, wolf and others, are, for the most part, poorly done. Aside from the wolf's head at Font-de-Gaume, they are mere crude sketches. Again, many of the game animals are painted with arrows penetrating their bodies in the most vulnerable places, as the heart region. Other scenes suggest the multiplication of game and hence the continuation of the food supply.

The importance of the game to these hunters can not be overemphasized. Once a primitive people establish a certain diet, it is most difficult for them to depart from it. This is especially true when the game also supplies the household needs and even tools and weapons. Years ago a Sioux warrior said to an army officer stationed in a fort on the upper Missouri, "The buffalo is our friend. When he goes all is over with our people." The truth of this statement is brought home to us by an enumeration of the things that the buffalo supplied. Besides food, it gave clothing, tents, blankets, beds, leather for lariats, hide for boats and a shroud for the death journey. Nor was this all; its horns were used for flasks and ornamental headgear and its teeth were often strung in

necklaces. Indeed, without this beast the Sioux would have been in a sad plight.

An age-old custom and one which is still practiced among many primitive tribes of to-day is the practice of magic to ensure the obtaining of food. Whether the Magdalenians practiced such magic is of course not known. But the study of their pictures makes such interpretation as least possible. The wounded animals drawn on the dark cavern walls may have been so drawn that the powers of magic would assist the hunter in bringing down his quarry. The same principle was exercised by the North American Indian who, as Frazer tells us, "believed that by drawing the picture of a person in sand or clay and then pricking it with a sharp stick or doing it any other injury they inflict a corresponding injury on the person represented. A similar superstition is indulged in to promote and increase the food supply. The females are spared as much as possible in the hunt and magic is resorted to by drawing pictures that bear upon the multiplication of game." We can not escape the fact that such drawings are numerous in the Paleolithic caverns.

It is a short step from magic to priestly rituals which rapidly became esoteric in character. This readily accounts for the use of the deepest and most inaccessible parts of the caverns for the locations of shrines and magic manifestations. Reasonable as such conjectures may be, there are some facts that raise objections to their complete acceptance. It may be that pictures were made on the shelter walls or just within the entrance and have since been obliterated by weathering. Many caverns show indications of human occupancy near the entrance; hence the unusual condition of having home and temple under the same roof is encountered. Thus it may be that these ancient painters were merely artists for art's sake.

There are many other questions about the life and habits of our ancestors of the stone ages that come swarming to one's mind. We can never hope to obtain full answers to all of them, but when one considers the vast amount of reliable information that has been discovered, especially during the last twenty years, one must needs believe that other veils will be lifted which will admit us to further knowledge.

THE MARRIAGE OF KIN

By PAUL POPENOE
COACHELLA, CALIFORNIA

EVERY now and then two healthy, happy young people announce that they intend to marry. Because they happen to be cousins, there is an immediate uproar among the relatives of the lovers. Gray heads are shaken ominously; the curse of Heaven is prophesied on the marriage. If the children resulting from it do not turn out to be feebleminded deaf-mutes, it is predicted that they will at least be marked by other evidences of degeneracy and defect, which will leave their presumptuous parents' heads bowed in lifelong grief.

In a good many cases, the aspiring lovers are frightened out of their intention. In more cases, they go ahead, with lovers' usual indifference to advice, and marry. Thus there are probably few of the older American families in which at least one cousin marriage can not be found.

In due time babies put in their appearance. Usually nothing is wrong with them; all the relatives agree that they are type specimens of infantile perfection, and the evils of cousin marriage are forgotten until the next proposed match is announced, when the old wives begin their clamor again. The prevalent opinion is embodied in legislation, which in more than a third of the states makes marriage between first cousins illegal. Oklahoma extends the prohibition to second cousins.

A study of the customs of other peoples, past and present, shows that among most of them consanguineous marriage of near degree has been forbidden or regarded as undesirable; and in many instances the fear of resulting defective progeny seems to underlie the prohibition. The tabu may be carried to such excess as in China, where the marriage of two persons with the same surname is forbidden.

On the other hand, it is not difficult to find instances where consanguineous marriage is common, even in the closer degrees which are now universally regarded by civilized people as incestuous and horrifying. Thus, among the ancient Hebrews, Sarah was Abraham's half-sister, and Moses sprang from a marriage between a nephew and his paternal aunt, while even in the time of David a marriage between brother and half-sister was regarded as permissible (II Samuel 13:13), although it had been forbidden by the levitical code.

Neither Moses nor Isaac, products as they were of incestuous unions, can be described as a bad recommendation for the system. They were not marked by any "stigmata of degeneracy." But the most extraordinary evidence as to the biological effect of the marriage of kin is to be found in ancient Egypt, where matings between relatives of the closest degrees were both common and fashionable, and data on them are available during a period of at least 2,000 years.

Gods set the example, Osiris having married his sister Isis. Common people followed this example, but it is to the royal family that one can turn for most satisfactory evidence, since contemporary biographies and portraits of the rulers are available, and in many cases the actual mummies of the individuals are extant for examination. The results of such an examination, made by the late Sir Marc Armand Ruffer and published in his *Studies in the Paleopathology of Egypt,* are of too much interest to be left buried in pages seen only by a few special students.

For royalty, consanguineous marriage was almost a necessity, due to the fact that throne and property were inherited through the woman—mother or wife—as legal head of the house; while on the other hand the man was charged with responsibility for the actual executive work that devolves upon a monarch. It was very doubtful, as W. Flinders Petrie says, "whether a king could reign, except as the husband of the heiress of the kingdom." The only way, then, to keep the royal power in the family was for the nearest male descendant of the king to marry the heiress, who was likely to be his sister. This curious state of affairs is no doubt largely responsible for the fact that in genealogies of the dynasties one brother-sister marriage after another is found, the list varied only by the occasional introduction of a slightly more remote relative.

The XVIII dynasty, which ruled Egypt in the sixteenth, fifteenth and fourteenth centuries before Christ, probably represents as high a point as Egypt ever reached, and it is accordingly the one chosen by Dr. Ruffer for detailed study. It began when the Hyksos were driven out of the country. These hated invaders were nomads who had held Egypt for some 200 years: it was in their time that the Israelites settled in the Delta. Ahmose I, founder of the dynasty, drove the foreigners out of the kingdom and made it more secure against future invasion. Artistically, his reign is marked by commencement of restoration of the great architectural monuments of Upper Egypt.

He married his sister; their son Ahmenhotep I extended the empire by reconquering Nubia, repelling the Libyans, and carrying an invasion of Syria as far as the Euphrates river. So much vener-

ated was he by the people that divine honors were paid to him for 600 years after his death.

He, too, married his sister. Their daughter Aahmes married her half-brother Thutmose I, who consolidated his father's work in Nubia and Syria, and was a noted builder at home.

The daughter of these two, Queen Hatshepsut I, married her half-brother Thutmose II; she overshadowed her husband and was the actual sovereign. She proved to be a wise ruler of far-reaching influence—the greatest queen of Egypt.

She was succeeded by her nephew and stepson Thutmose III. This monarch's character, says J. H. Breasted, "stands forth with more color and individuality than that of any king of early Egypt, except Akhnaton. We see the man of a tireless energy unknown in any Pharaoh, before or since; the man of versatility, designing exquisite vases in a moment of leisure; the lynx-eyed administrator, who launched his armies upon Asia with one hand and with the other crushed the extortionate tax-gatherer. . . . His reign marks an epoch, not only in Egypt, but in the whole East as we know it in his age. . . . He built the first real empire, and is thus the first character possessed of universal aspects, the first world hero." And he was the product of five unbroken generations of brother-sister marriage.

This great king married his half-sister, and their son Amenhotep II was a man of extraordinary physical strength, who claimed that none of his subjects could bend his bow. His reign was marked by energy and military success. He married Tiaa, whose pedigree is uncertain, although she has been called his half-sister.

Their son, Thutmose IV, was an energetic lion-hunter in his youth and a successful leader in war after he ascended the throne. His marriage to a Babylonian princess resulted in a son, Amenhotep III, who succeeded to the throne. As there were no more kingdoms within easy reach to be conquered, his reign is marked by great development of the pursuits of peace—by expansion of commerce and patronage of the fine arts. He took a Syrian princess as his bride; their son Akhnaton, characterized by religious enthusiasm and a high moral standard, brought the dynasty to an end.[1]

Summarizing, Dr. Ruffer observes: "The characteristics of the XVIII dynasty were . . . tireless energy, which enabled Egypt to resist its foreign foes, to carry the Egyptian flag abroad, and to establish wise government at home; and an enlightened taste for the fine arts, most forcibly shown in the artistic reforms of Akhnaton. In these nine generations, issued from consanguineous marriages, there is no diminution of mental force. The energy charac-

[1] He was succeeded by his step-son, the well-advertised Tutankhamen.

teristic of Ahmose I is found 200 years afterward in Akhnaton, used, it is true, for different objects and higher ideals, but as intense in 1375–1358 as it was in 1580–1557 [B. C.]."

Of the specific evils popularly attributed to consanguineous marriage, one is infertility. Data are lacking to compare the fertility of the members of this dynasty with that of other families of the same period, but it is certain that the fecundity of the royal family was not below normal.

Again, children born of consanguineous unions are sometimes said to be short-lived. While the average duration of life in Egypt in that period is unknown, it is easy to ascertain the longevity of the male rulers of this dynasty. Eight of them show an average of 44 years, which is not bad, considering the stress to which a military ruler is subjected.

The physical proportions of these rulers, as measured on their mummies, are good—many of them were men of notable strength. "There is no evidence to show that idiocy, deaf-mutism, or other diseases generally attributed to consanguineous marriage ever occurred among the members of this dynasty, and as far as can be ascertained from mummified bodies, masks and statues, the features of both men and women were fine, distinguished and handsome."

"The result of this inquiry is that a royal family, in which consanguineous marriage was the rule, produced nine distinguished rulers, among whom were Ahmose, the liberator of his country; Thutmose III, one of the greatest conquerors and administrators that the world has ever seen; Amenhotep IV, the fearless religious reformer; the beloved queen Nefertari, who was placed among the gods after her death; Aahmes the beautiful queen, and Hatshepsut, the greatest queen of Egypt," the dynasty ending in Akhnaton, who is credited with being the first monotheist and monogamist among the rulers of his country. "There is no evidence that the physical characteristics or mental power of the family were unfavorably influenced by the repeated consanguineous marriages."

The kings and queens of the XIX dynasty, which followed, were probably lineal descendants of the foregoing. "Rameses II, the great historical figure of this dynasty, married two of his sisters, and had four children by the first and three, or possibly four, by the second. He is said to have married two of his daughters, but the evidence on this point is not conclusive. By other wives and concubines the king is said to have had 106 other sons and 47 daughters, therefore this descendant of a long line of consanguineous marriages can not be said to have been infertile."

A thousand years later another dynasty, of wholly different race, offers additional striking evidence on the effects of the mar-

riage of near kin. This is the dynasty of the Ptolemies, founded after the death of Alexander the Great by his bold and patient general Ptolemy Soter. The first four kings of this series were not sprung from consanguineous marriages; it is, therefore, particularly useful to compare them with the later rulers, among whom brother-sister matings had become customary.

The general reputation of the Ptolemies is of course bad: morally they were of the conventional type of Oriental despot, wicked and unscrupulous. But they were not weaklings: whatever their moral defects (for which environment must receive some credit, as well as heredity) they displayed abundant physical and mental energy. The direct line of the Ptolemies came to an end with the twelfth ruler of the dynasty, "not because the women had become barren, or the men unable to beget children, but because all the male descendants born in legitimate wedlock had been killed or exiled."

The sceptre was taken up by Auletes, an illegitimate son of Ptolemy X, and was finally laid down by his daughter Cleopatra VII, whose fame in history is sufficiently great, although not altogether spotless. It must be remembered, however, that public opinion as to her character has been based either on the accounts of her contemporary enemies, or on those of a long line of romancers, ranging in calibre from William Shakespeare and John Dryden down to the latest writer of vaudeville songs or "Sunday Supplement" thrillers. Nothing can be said against her character until she fell into the hands of two old roués, first Julius Caesar and later Mark Antony. She came to the throne a young girl, facing the impossible task of preserving her country and dynasty from the conquering power of Rome. Lacking military strength, she relied on blandishment and intrigue; and her amours with Caesar and Antonius must be regarded from this point of view among others. It is not necessary to attempt to whitewash the character of Cleopatra or that of any of her long line of incestuous ancestors, in order to establish the fact that, almost without exception, they demonstrated physical and mental energy, reasonably long life if they did not meet with violent death, and absence of the defects which popular prejudice attributes to consanguineous marriages of a much more remote degree than those here considered. Dr. Ruffer's summary seems to me well balanced:

> The Ptolemies born from consanguineous unions were neither better nor worse than the first four kings of the same family issued from non-consanguineous marriages, and had the same general characteristics. Their conduct of foreign affairs and internal administration was in every way remarkable and energetic. They were not unpopular in their capital, and the Alexandrians

rallied round their ruler when the Romans entered Egypt and resisted the foreigner.

Though much has been written about the awful sexual immoralities of the Ptolemies . . . their standard of morality was certainly not lower than that of their fellow-townsmen.

The children from these incestuous marriages displayed no lack of mental energy. Both men and women were equally strong, intelligent, capable and wicked. Certain pathological characteristics doubtless ran through the family. Gout and obesity weighed heavily on the Ptolemies, but the tendency to obesity existed before the consanguineous unions had taken place.

The male and female effigies on coins are those of very stout, well-nourished persons. The theory that the offspring of incestuous marriages is short-lived receives no confirmation from the history of the Ptolemies. . . . Omitting those who died violent deaths, the average length of life of the Ptolemies was 64 years.

Sterility was not a result of these consanguineous marriages. No case of idiocy, deaf-mutism, etc., in Ptolemaic families has been reported.

In these two noteworthy dynasties, close inbreeding was practiced on a larger scale, for a longer period of time, than in any other cases known to me in detail in the human species. None of the evil results generally attributed to cousin marriages seems to be manifested. The consequences more nearly recall the results achieved by live-stock breeders, who long ago discovered and applied the fact that close inbreeding is the foundation of all great breeds and families of domestic animals.

Scientifically, the effects of inbreeding are now well understood. They represent merely the union of similar heredities; for instead of possessing wholly different inherited traits the two mates are, by virtue of their common ancestry, possessors to a greater degree than usual of the same inheritable units.

Thus, if the ancestry of the two is good, their children will be benefited by receiving a double dose, so to speak, of certain good traits of their ancestors. When the parents are carefully selected, as by a live-stock breeder, who culls out all the animals with bad qualities, there is no quicker way of building up a fine breed than by inbreeding. In the dynasties which have been chronicled above, the stock was in a way selected at the start—only select and superior individuals would have been capable of founding dynasties under the then existing conditions. By theory, good results would have been expected from the inbreeding of such selected stock, and in fact it appears that the results were, on the whole, excellent.

On the other hand, in a stock that carries defective heredity, the children are doubly handicapped. Moreover, it often happens that a hidden trait in the family ancestry is brought to light, when two related lines of descent are united in a single individual: thus a feeble-minded child may be born in a cousin mating, where feeble-

mindedness was latent or recessive in the ancestry and had not previously made itself manifest. It is cases like this that have given consanguineous marriage its ill repute, although recessive traits may also appear most disconcertingly in the offspring of unrelated persons, if the same trait happens to occur in the ancestry of each.

Defective children born after a marriage of kin were naïvely explained by the supposition that there was something inherently wrong about the marriage of relatives, when in fact it was the ancestry that should have been blamed. In passing judgment on a proposed marriage, therefore, the vital question is not "Are they related by blood?" but "Are they carriers of desirable traits?"

In a stock that is defective to start with, consanguineous marriage brings the evil traits to light with surprising rapidity. The archives of heredity are full of pedigrees, gathered for the most part in poor farms, jails and other custodial institutions, where almost every member of a family, for generation after generation, is tainted in some way. When it is found that numerous cousin marriages are represented in such a pedigree, it is altogether natural that these marriages should be looked on with suspicion.

Biologically, then, the marriage of kin may be a good thing or a bad thing. It depends on the kind of germ plasm these kin have received from their progenitors. If the same congenital defect or undesirable trait does not appear in the three previous generations of two cousins, including collaterals, the individuals need not be discouraged from marrying if they want to.

But, from a broader point of view, the strictly genetic considerations are not the only ones to be weighed in passing judgment on consanguineous marriage. Other considerations are sometimes not given the weight that they deserve.

Some of the opposition in modern civilized countries to consanguineous marriage is doubtless a survival of the establishment of prohibited degrees by the Roman Catholic church during the middle ages. The extent of these prohibitions went far beyond the limits which any biologist would have set: a well-known survival, only lately abolished by Parliament in England, was the prohibition of marriage between a man and his deceased wife's sister.

Without stopping to inquire the real motive for the erection of these bans to marriage between blood relatives or sentimental connections, one may recognize the validity of the argument by which Roman Catholic theologians now justify them, namely, that the kind of love which leads to mating and the kind of love which binds the members of a family together are two different things which should not be mixed. Psychologically, this proposition will be indorsed by almost every one. In late years particularly has it been

pointed out that too great attachment between members of the same family, originating in youth, imposes a heavy handicap on the personality, ever vainly seeking to free itself from the cramping influence of this emotional bond in order to take its place in the outside world.

Eugenically, on the other hand, it is desirable that the individual be trained to look outside his own family circle for a mate, because in this way new and, presumably, valuable family traits will be brought into the stock; and latent undesirable traits will be denied the expression that they might get if two persons, related and hence carrying the same trait, should marry.

Quite apart from the biological aspect, moreover, it is evident that normally a young couple are better situated, if they have the counsel, influence and help of two different family circles to fall back on, than if they have only the one in which they were together brought up.

In summary: The study of these extraordinary Egyptian genealogies is of great interest to the biologist, because it affords such a striking confirmation of the theory of genetics. But it offers no encouragement to the establishment of consanguineous marriage as a normal rule. In isolated cases in healthy stock, cousin marriages are not to be opposed—they may even be recommended. Charles Darwin, whose children are the offspring of a cousin marriage, is one of the standard illustrations. But, at best, a cousin marriage usually connotes a narrow horizon and lack of opportunity on the part of the mates to meet a wider circle of eligible young people; and one of the cares of parents should be to give their children as wide a circle of eligible acquaintances as possible, in order that sexual selection may have full play.

As to consanguineous marriage in general, then, and particularly the closer degrees of it which go by the name of incest and are criminal under the laws of modern civilized nations, the case seems to be fairly clear. The individual's interest agrees with that of the race in requiring, at least after the period of adolescence, that the individual's affections should be projected out of the home and family and not confined within them.

METEORITES

By Professor ARTHUR M. MILLER
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METEORITES, being solid bodies which come to earth from celestial space heated to dazzling brilliancy on the surface from friction with the air and detonating with terrifying intensity as they set up violent atmospheric compression and rarefaction waves, would appear to carry with them proofs of their extramundane origin as incontestable as could well be demanded. Yet it was not until the closing years of the eighteenth century that the scientific world became convinced of the reality of these objects and that they did actually "fall from the sky." It is said that even President Thomas Jefferson, progressive though he was in the science of his day, was skeptical about such occurrences, replying to the assurances of a friend that the actual fall was well attested by two Yale professors that he "would prefer to believe that two Yankee professors[1] would lie rather than that stones could fall from heaven."

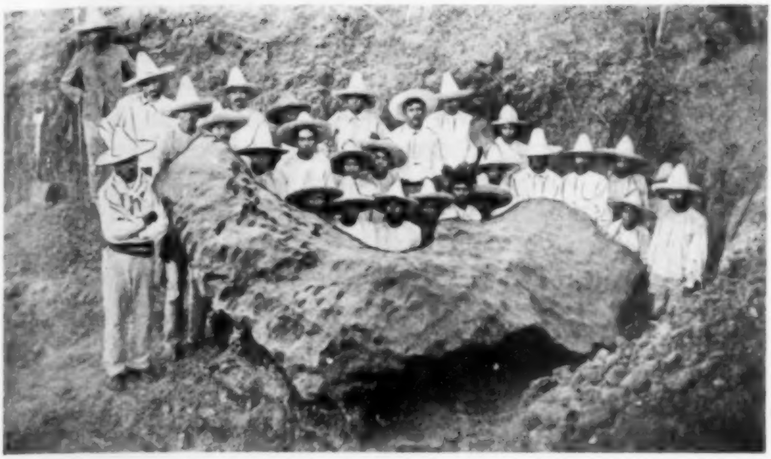
It is all the more remarkable that skepticism should have prevailed as to the reality of these occurrences when one considers to what remote antiquity records of the falling of these bodies extend. Such a record we undoubtedly have in the reference in the book of Acts of the New Testament to the "image which fell down from Jupiter" at Ephesus, in the making of silver miniature replicas of which Demetrius and his fellow-craftsmen built up such a thriving business.

Despite the fact that the aggregate number of meteorites (estimated to be between 600 and 700) which come to the earth each year seems to be quite large, very few people have been killed by them. Sir John Herschel, writing near the middle of the last century, is the authority for the statement that the number up to that time had been four. The only instances of death from this cause of which there has been preserved specific data are two—that of a priest or monk in Northern Italy in 1511 and of a person in India in 1827. This remarkably small mortality due to them strikingly demonstrates how infinitesimal is the space on the globe physically occupied by human beings in comparison with the remainder of terrestrial surface.

[1] Professors Silliman and Kinsley, in their report on the Weston, Connecticut, meteoric fall. Transactions of the American Philosophical Society, Philadelphia, Vol. 6, pp. 323, 325, 1809.

THE BACUBIRITO, MEXICO, METEORITE

One of the largest meteorites known. Weight about 27 tons. From Dr. O. P. Farrington's work on "Meteorites" by courtesy of the author.



THE GREAT BACUBIRITO METEORITE
State of Sinaloa, Mexico, and the Mexican workmen who dug it out.

COMPOSITION AND CLASSIFICATION OF METEORITES

While meteorites have brought no new chemical elements to the earth, some of the combinations of elements in them are unique. In all some forty elements have been recognized in them, but fifteen of these are very rare. Most conspicuous is metallic iron alloyed with nickel, the latter usually forming eight to ten per cent. of the iron-nickel alloy. Meteorites which consist entirely or largely of this iron-nickel alloy are known as "siderites" or simply "irons." The Anighito (if indeed this be truly meteoric and not simply basaltic, and hence telluric in origin), brought to the American Museum of Natural History from Cape York, Greenland, by Admiral Peary is such an iron, weighing about 36½ tons. Another siderite in the same museum, the Williamette from Oregon, weighs 15.6 tons. There are a number of large irons (about six), from three to fifty tons in weight, which fell in northern Mexico. These were considered sacred objects by the Aztecs, and before the coming of the Spaniards a number of them with infinite labor had been removed to Mexico City, where they are still on exhibit. The largest of these Mexican irons—the Bacubirito—still lies where it fell in the state of Sinaloa. Dr. Henry A. Ward, under whose supervision it was completely exposed about or shortly before 1892, estimated its weight at close to 50 tons. It probably weighs about 27 tons.

All meteoric nickel-iron, when polished and etched with nitric acid, exhibits a characteristic reticulate crystalline structure, named after the discoverer, Professor Alois von Widmannstätten, of Vienna, the "Widmannstätten Figuren." This structure was considered an infallible test for metallic iron of celestial origin until

it was found in native nickel iron in basalt on Disco Island, Greenland, by Baron Nils Nordenskiöld in 1870. The finding of such iron of undoubted terrestrial origin, some of it in masses weighing as much as 20 tons, and in the same general region as the "Peary Irons" found at Cape York, Greenland, has, according to Fridtjof Nansen, raised serious doubts as to the meteoric origin of the latter, though they have been accepted as genuine by the best authority in this country and placed on exhibit in the American Museum as including the largest in captivity.

There is little doubt but that the human race first learned the use of iron from sideritic masses of celestial origin. Significant in this connection is the structure of the ancient Damascus sword blades, celebrated for their toughness and flexibility. They possessed a laminated reticulate structure closely resembling meteoric iron. First made from iron of celestial origin, to which such structure was inherent, Damascus blades, as the makers learned to obtain iron from terrestrial sources by smelting and to substitute it for meteoric iron, were so wrought as to retain the simulation of this original laminated reticulate structure: "None genuine unless branded throughout the brand."

Another group of meteorites consist largely of silicates of magnesium, calcium, aluminum, etc., through which are disseminated

CAPE YORK SIDERITE

Weight 36½ tons. Dr. Henry A. Ward "about to lift it." From photograph as it lay in the Brooklyn Navy yard, courtesy of Dr. E. O. Hovey.

specks of metallic nickel-iron. These are called "aerolites." On account of their lighter specific gravity and the grayish, stony appearance of their interiors, they are commonly referred to, in distinction from "irons," as "stones."

There is another and smaller group of meteorites intermediate in character between the siderites and aerolites, known as "siderolites," in which the iron constitutes an irregular lattice or mesh work with the stony matter filling the meshes. Sideritic structure grades into aerolitic through siderolitic.

According to Professor George P. Merrill of the National Museum, Washington, D. C., there had been catalogued to January 1, 1919, for the world, 788 distinct falls. Of these, 367 would be classed as "irons," 403 as "stones," and 31 as belonging to the intermediate group. Of the 367 irons, there have been seen to fall 17, or less than five per cent.; of the 403 stones, there have been seen to fall 354, or nearly 88 per cent.; and of the 31 belonging to the intermediate group, there have been seen to fall five, or 16 per cent. This disparity in the number seen to fall in the different groups, especially when the irons and stones are compared, calls for an explanation. One theory is that iron meteorites, though really less numerous in the soil than the stony, are, on account of their metallic nature, more readily detected than the latter. A farmer, plowing, or a workman, digging a ditch, is very apt to stop to examine any metallic object his plow or point of pick may strike. In case this should happen to be a meteorite, even though not recognized by the finder as such, it is laid aside as a curiosity and, sooner or later, its real character is detected by some one. A stony meteorite struck under the same conditions is to the one who turns it up simply a stone and nothing more. Professor Merrill, however, is not satisfied with this explanation, calling attention, for one thing, to the greater destructibility of the irons through oxidation, and he is disposed to champion the view that there has been in recent geologic times an actual decrease in the number of falls of iron meteorites, or, as he puts it, there has been in that time a "decreasing basicity in meteorites."

The late Professor William H. Pickering, of the Harvard Astronomical Observatory, Cambridge, Massachusetts, offered still a different explanation. Calling attention to the facts that many more iron meteorites have been found in the western than in the eastern hemisphere (nine times as many in proportion to the stony meteorites, a matter that appears to have been overlooked by Professor Merrill), that on the western hemisphere are concentrated most of the *large* irons and that all irons large and small have never been found buried to any great depth in the soil, he held that all or most of

these irons fell at one time and that this time was comparatively recent. The agent he invoked for broadcasting them is a comet, the head of which, composed of masses of nickel-iron, he thought "side swiped" the earth on its western hemisphere side in such a way as to cause the brunt of the impact to be borne by the northern part of Mexico and adjacent portions of the United States. Here has been found, much of it in large masses, the greatest amount of meteoric iron known from any other region of equal area in the world. Here, too, near Canyon Diablo in Arizona, is the famous "Coon Butte Crater," a circular depression about 600 feet deep (originally probably 1,400 feet deep) surrounded by a raised rim about four fifths of a mile in diameter, which, in the character of the raised rim and the vitrified and pulverized sand forming the floor, possesses all the characteristics of a crater of impact, as much so as any of the shell craters made by the heavy projectiles fired from German guns in northern France during the late world war. These characteristics and also the fact that large quantities of meteoric iron, amounting in all to date to 15 tons, have been found scattered about this crater early led American geologists to accept the comet-impact-theory as the most satisfactory explanation of this remarkable phenomenon. Now has come forward Professor Pickering with additional support for its comet origin (though only the effect of a small portion of the comet), derived from a study of the distribution of iron meteorites over the surface of the earth.

Pre-mundane History of Meteorites

It appears to be almost certain that meteorites, some two or three of which the average person is entitled to see fall to earth within the period of an ordinary lifetime, constitute the heads of small comets. The very minute particles that trail along after the heads of large comets, constituting in part the tails of them (but if they

Coon Butte Crater, Arizona
From photograph, courtesy of Dr. George P. Merrill.

are recurring ones and have been running in their courses a long time, distributed well around their whole orbits) on being heated to incandescence and dissipated by friction with the air, produce the phenomenon of "shooting stars," several of which any one may see shoot across the heavens on almost any clear night.

This meteoric material is known to be travelling at very high velocities—some of the larger masses at rates as high as 26 miles per second, and some of the dust-like particles at rates as high as 45 miles per second. Now 26.16 miles per second is the "parabolic velocity" for celestial visitors to our solar system. That is, it is the maximum velocity a body falling towards our sun can attain by the time it reaches the distance from the sun of half the diameter of the earth's orbit, even though it may have been falling from the utmost confines of space. In other words, a body may have been falling towards our sun from so far away that it has been falling forever, yet this is a velocity that, at the distance of the earth from the sun, it can not exceed. Noting this accord between the common velocities of meteorites and certain comets, astronomers were formerly disposed to look upon all meteorites and comets as originally extraneous to the solar system, having been attracted into it from very remote distances. The less than the parabolic velocities possessed by some of them, resulting in their moving in elliptical orbits, was accounted for by retardations produced by perturbations of the planets. Quite recently, however (see announcement in *Science* for January 19, 1923), Professor Stroemgren, royal astronomer of Denmark, as the result of mathematical investigations made on comets for the last twenty-two years, seems to have refuted this old idea that comets (and presumably meteorites also) are "vagrant wanderers from interstellar space," and proven to the contrary that those with elliptical orbits have always formed a part of our solar system. Those that he finds moving in parabolic or hyperbolic paths he accounts for as outcasts from our solar system, through their once closed elliptical orbits, having been thrown into open curves by accelerative perturbations of the planets.

Granting, then, that meteorites (and comets) have always formed part of our solar system, what has been their history within that system? A partial answer to this question is to be found by a study of the structure of meteorites. It is quite certain from such study that they have not always been cold bodies flying through solar space, but must have at one time been molten and subsequently cooled under great pressure. This is evidenced by their coarse crystalline structure and their occluded gases. Even CO_2 in a liquid condition in minute cavities has been found in some of them. Such facts can be accounted for only on the theory that

meteorites (and comets) once formed the interiors of large planetary bodies or of a former sun. These facts harmonize well with the Chamberlin-Moulton theory that our present solar system is formed out of the wreck through "tidal disruption" of a former solar system, the disrupting agent being another and much larger sun, in proximity to which our former solar system at one time came. In accordance with this theory meteorites are fragments of this former solar system—planetesimals out of which our present solar system is still being built.

Effects of Collision between the Earth and Meteorites

The paths which the earth and a meteorite are pursuing around the sun may intersect, and it may happen that both these bodies arrive at this intersection at the same time. This will result in a collision which will be head on, tail end or at some angle in between, the effective velocities in any case being sufficient to heat through friction with the air the outside of the meteorite to incandescence. As the outside melts it is rubbed off by the friction, leaving the brilliant, but usually quickly disappearing trail that is the conspicuous phenomenon in the case of every meteor. The only evidence the meteorite retains of this melting when it reaches the earth is a thin surface glaze, which is darker in proportion to the basicity of the body, and also a fluting formed of disconnected impressions, like thumb marks, which radiate from the point directed forward in its passage through the air. The friction of the air and also the cushioning of it in front of the rapidly moving body quickly slows down its initial velocity, so that, except in the case of a very large meteorite, which would almost certainly be iron, this velocity is entirely checked before the body reaches the earth. At this point of checking, usually at a height of from eight to twelve miles, the meteorite (in nearly every observed instance a stone) breaks up with loud detonations, and the main mass and its fragments drop to earth with accelerating velocity of bodies falling from this height under the influence of gravity. The smaller fragments, on account of the more effective resistance of the air, often have so slight velocities on reaching the ground that they do not penetrate the surface even of soft ground, and have been known not to break ice only a few inches thick.

Meteorite Hunting

The writer has been engaged with some measure of success for twenty years in endeavoring to run down and locate any meteorites which in descending to earth have come within his horizon. The first one of these, which he was fortunate enough to be able to

observe through its whole visible course and measure the altitude and azimuth of its point of bursting, was on November 15, 1902, at 6:45 in the evening. By requests inserted in the press of Kentucky he was able to secure four other observations which gave the same data as seen from other widely separated places in the state. A plotting of these observations indicated the knobs of southern Bath County, Kentucky, as the place where this meteorite should have fallen, and almost immediately came word from that section that a fragment of it had been picked up by one Buford Staton from the road in front of his cabin, where it had fallen. This was secured by the school superintendent of the county, Mr. Daugherty, and sent to the University of Kentucky for examination. Dr. Henry Ward, who was then alive, was notified. He came to Lexington and purchased the stone from Mr. Daugherty for $200. It weighed 13½ pounds. Professor Henry C. Lord, of the Emerson McMillin Astronomical Observatory, Ohio State University, Columbus, Ohio, also saw this meteorite descending low in the southern heavens, and through the public press called for observations. Combining the replies which he and the writer received from numerous observers it was determined that this body was seen in its fall over a north and south belt some eight degrees in width, extending from middle Ohio to the Gulf of Mexico. Despite this north and south range of observation, the horizontal component of the meteorite's path was from west to east. The apparent contradiction involved in these facts is reconciled by considering the time of day at which the meteorite fell. At that season of the year (November) it was dark at 6:45 P. M., and many persons were out of doors along a north and south belt in that time zone, where conditions were favorable for seeing a meteor flashing across the sky. Further east the time of night was later, and not so many people were out of doors. To the westward it was yet day where a meteor would not so likely light up the sky sufficiently to attract attention.

In 1919 the writer had another opportunity to study the phenomenon of a falling meteorite and recover some of the fragments. It fell near midday on April 9, and its horizontal component of fall was from south to north, coming into southern Kentucky from over the state of Tennessee. In the latter state, the sky was cloudless, and, though at midday, the meteorite shone with a brilliance above that of the sun. Over Kentucky hung clouds obscuring it from view, but, by this time, the stone was near enough the earth to be detonating with terrific violence so that its position from point to point could be located by the sound. Indeed, the concussions were so violent as to shake buildings, leading the county papers of that region first to report the phenomenon as an earthquake. These

vibrations in buildings were noticed a long distance from the point of fall, being detected as far away as Lexington, 85 miles to the north. In coming north over Kentucky, this meteorite's horizontal component paralleled the line of the Cincinnati Southern Railroad, and it is an interesting fact that the tower men along the line of this road as far as Danville kept by telephone ahead of this "commotion" coming up the road (that is, ahead of the sound of it). Fragments of this meteorite—an aerolite of remarkably low basicity—being composed in fact mainly of silicate of magnesium—began to spall off at Sawyer Post Office, near Cumberland Falls, and some 54 pounds of the material were secured by the writer from that vicinity. There is little doubt, however, that the main mass, which must be very large for an aerolite, went on farther north and to-day lies buried somewhere in the very rugged portion of Pulaski County, north of the Cumberland River.

On May 30, 1922, at 7:30 P. M., central time, a meteorite with a west to east horizontal component passed over the states of Indiana, Kentucky and West Virginia. It was seen by a large number of people in those three states and also in Ohio and Virginia. The writer, in response to a request published in a number of newspapers, obtained records of observations from a considerable number of eye-witnesses in these five states, but, though these persons exhibited the most cordial desire to contribute information which would lead to the discovery of this celestial body, so few of them gave estimates of azimuth and altitude of the point of bursting or disappearance of the meteorite as seen from the point of observation couched in terms that were intelligible that little use could be made of most of the information received in calculating very exactly the place of its fall. There were, however, enough intelligible data received to enable the writer to select Greenbriar County, West Virginia, one of the most mountainous counties of the state, as the most probable one in which it came to earth. In pursuing meteorite hunting as a pastime, the writer is continually having it brought home to him how few adults, even those entitled to be placed in the intelligent class, when it comes to intelligible expression give any indication that their conception of the earth in its relation to the universe is any less primitive than that of the ancient Chaldeans, Hebrews and Egyptians, or of Voliva of Zion City. However stoutly these same people may assert their belief in the Copernican theory, practically their conceptions are those of persons living on a flat earth, covered over by a bowl-shaped solid sky, on which measurements may be made in feet, and travelling along which a celestial body, in passing to the horizon, comes to earth, usually not farther away than over the next hill, or at most, not beyond the

Bath Furnace Aerolite
Fell in Bath County, Kentucky, November 15, 1902. Weight 180 pounds. From photograph by the author.

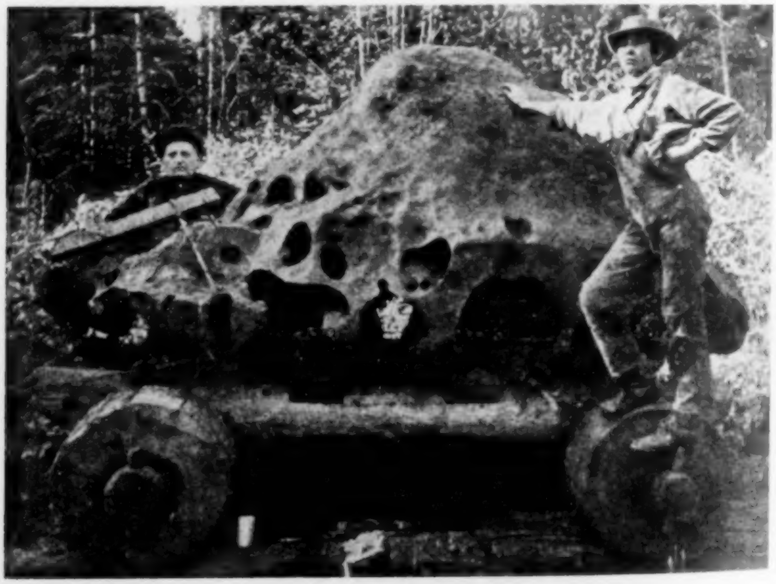
next county. Let us hope that when our present boy scouts come to maturity, having been trained in a proper knowledge of their relation to their physical environment, "meteorite chasing" may take on the aspects of a more exact science than it has to-day.

Legal Contests for the Possession of Meteorites

A number of interesting questions of ownership have been raised by the finding of meteorites. Where they have got into the courts, they have all been settled in favor of the owner of the land on which the meteorite fell, in accordance with the decision rendered in the first case of the kind in this country—that of Goodard v. Winchell, Supreme Court of Iowa, October 4, 1892. Professor H. V. Winchell, state geologist of Minnesota, had purchased for $105 a 66-pound aerolite from Peter Hoagland, who dug it up from the land of John Goodard, in Iowa, where it had fallen May 2, 1890. The decision rendered in favor of the plaintiff, Goodard, in the lower court, was reaffirmed in the Supreme Court on the ground that a meteorite became, by falling on land, as much a part of it as boulders transported thither by glacial action.

A question of ownership was raised in the case of the main mass of the Bath County, Kentucky, meteoric fall. Mr. Pergrem, resident of the knobs of southern Bath County, while squirrel hunting

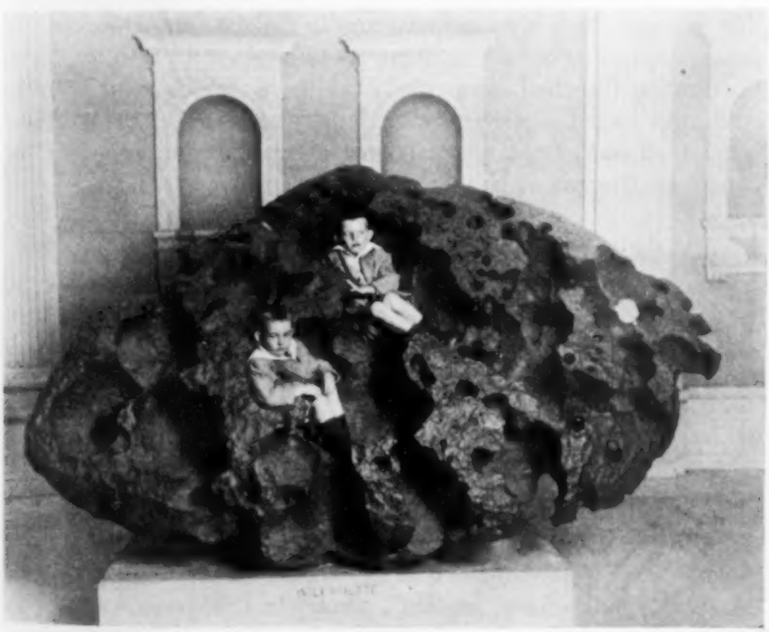
in the early spring of 1903 on a large tract of wild land belonging to the "Ewing Heirs," noticed where the tip of a white oak sapling had been clipped off. Suspecting that this had been done by a piece of the meteorite, which, by its brilliant light produced and the terrific detonations occasioned, had so alarmed the inhabitants of the region in the previous November, he looked further and found a skinned place on another sapling. Lining up the direction as given by these two points, he noted where the meteorite would strike the ground, and, digging there, found a mass of iron weighing about 180 pounds, buried flush with the ground at the base of a small tulip poplar. With the aid of an old horse, he removed the meteorite on a sled to his house. A more prosperous cousin, also named Pergrem, who knew the 13½ pound fragment had brought $200, then traded him a cow for this main piece. It was on the front porch of this more prosperous Mr. Pergrem that the writer, who a few days after this transaction had made a trip to the region in order to obtain, if possible, some facts bearing on the trajectory of the meteor, first saw this specimen, and secured a photograph of it. On his return to Lexington, he communicated to Dr. Ward the news of this new find in a letter which was forwarded to him in Russia, whither he had gone after another meteorite. In due time came a cablegram from Dr. Ward in St. Petersburg, authorizing the writer to offer a certain sum for this latest and, evidently, main portion



THE WILLIAMETTE SIDERITE
Loaded on a truck, and the man and boy who thus "ran away with it."

of the Bath Furnace, Bath County, meteorite. In the meantime, however, the Ewing heirs had brought suit for possession of it, and Pergrem, the possessor, not wishing to face a lawsuit, relinquished all claim to it and demanded back his cow from his cousin. The matter remained in *statu quo* until the return of Dr. Ward. The case was then settled out of court by Dr. Ward paying the Ewing heirs $1,400 for the meteorite (there has been a big slump in the price of meteorites since Dr. Ward's death), with the understanding that $200 of it was to go to Mr. Pergrem, the finder. This fine specimen of an aerolite may now be seen in the Field Museum, Chicago.

Another meteorite over which there was an interesting legal contest was the Williamette iron already referred to. This specimen was found by a former Welsh miner, Ellis Hughes, on a tract of land adjacent to his own, belonging to the Portland Land Company. At first, he thought he had discovered an iron mine, but on further digging, saw the mass was detached, and realized he had unearthed a meteorite. The next thing was to gain possession. He did this by means of a low, heavy wooden truck, especially constructed for the prospective load, on which he managed to capsize the 15-ton iron, and then, with no other motive power than an old



WILLIAMETTE SIDERITE

Weight 15.6 tons. From photograph, courtesy of Dr. E. O. Hovey.

horse winding a rope around a capstan as a winch, which had to be moved and re-anchored as the truck with its load was drawn up to it, he and his fifteen-year-old son, working so quietly that winter that no one, not even his nearest neighbor, ever suspected what they were doing, dragged this iron three quarters of a mile from the property of the Portland Land Company on to his own land—the only case on record, according to Dr. Ward, of "any one ever having run away with a fifteen-ton meteorite." Naturally, on its being noised abroad what this Welshman had discovered and secured, the Portland Land Company brought suit for possession. When the case came to trial, the lawyer for the defendant put up a most ingenious plea. He alleged that in this case the meteorite was not "real estate" but "discarded personal property" belonging to whoever might find it; that it was an "Indian relic," known and revered from time immemorial by the then virtually extinct tribe of Siwash Indians. In support of this claim he introduced on the witness stand a very old Siwash Indian, almost the last of his tribe, who testified that this mass of iron had long been known to members of his tribe, who attributed to it magic virtue—that even as a youth he had been conducted to it by one of the old medicine men, and had it explained to him how, if arrows were dipped in the water that collected in the hollows of this iron and were then shot at game, they always went true to their mark. However, the judge, holding true to precedent, as all judges do, and citing the Goodard v. Winchell case, ruled that the meteorite went with the land, and issued a writ, placing it in possession of the Portland Land Company, from whom it was afterwards purchased by the American Museum of Natural History.

THE TIME OF DAY[1]

By Professor ALFRED H. LLOYD
UNIVERSITY OF MICHIGAN

First Part

I

"Pray, what time is it? Watchman, what the hour?" Some one replies, giving minute as well as hour. Or this: "The Twentieth Century of the Christian Era." So do little things of life and big, one's watch and history often come together. However sententiously, the wonderful hovers over the commonplace.

Whatever the time by hour or by century, it would seem safe to say that by some happy conjunction of circumstances, including the stars, we are all living in our present time, at this very minute or hour, or more grandly, we and millions of others the world over are contemporaries. Yet, so soon as said with seeming safety and also impressive as it really is to contemplate, is it after all quite true? Are even you, reader, and I and all our present fellow-beings necessarily contemporaries? True, by the clock on the mantel or in yonder tower or by the date, 1923, we are all in our own time and it certainly seems to be the same time; but are we and all our so-called contemporaries, far east or far west, north or south, are we, all of us, really of this present time? Do we, all of us, live now actually and responsibly? Are we, in our will and our action, not just in our existence, on time?

Beware of clocks. Beware of calendars; of mere chronometers and outwardly and abstractly accurate chronicles of all kinds. Too easily they give false notions; perhaps imparting unwarranted confidence and pride of progress, perhaps giving needless discouragement. Clocks and other formal histories have a certain nicely intellectual and instrumental value; also we all like to hear them tick or strike; we all like to hear of roundly numbered centuries and eras; but such formal times is not real time. The real twentieth century is a responsibility, not a date that merely "has it one better" over the nineteenth; and, in general, actual time and of course also actual space are what they are only relatively to the facts and to the meaning and life of them. Einstein, if I have at all under-

[1] This essay had its origin in an address given in March of the present year before the members and friends of the chapter of Phi Beta Kappa at Vassar College. The original address is here considerably revised and expanded.

stood him, would hold even the sun and the earth, the moon and the stars and the light from or to any of them to tests of time and space, not by mere abstract chronometer or cosmometer, but by the facts; by relative weights, then, not by mere formal and absolute measures. Not tarrying, however, for his thanks, just as an adventure of my own I insist that, whatever be true of space, real time is not the simple, tick-tock, straightforward and accurately datable thing we are in the habit of thinking it. Whenever two or three are gathered together in time, the time of their meeting very often suffers curvature or distortion of some sort. Thus, I submit that people there are to-day—are you, reader, and I, however obviously now come together, of their number?—who are straining the supposed integrity of time terribly by living actually, whatever the objective time-registers may say, either a century or two in the past or, as if with an equal but possibly compensating violence to timeliness, a century or two in the future.

If we must have reactionary and ghost-seeing conservatives, it is doubtless very fortunate that we get also impractical and futuristic dreamers. Whenever certain and radical changes are imminent and a distinct transition is the great sign of the day, both those groups do serve a purpose. At least, either alone would be disastrous and the conservation of life and its attainments and possibilities that the two together insure is plain. Moreover, the life of a people, when so divided between one untimely and distorting extravagance and another, opposing and balancing this, admittedly has a peculiar zest and vitality. It brings an analyzing and always very instructive and productive experience. There is, too, always something doing. But, to utter the obvious, such a divided life lacks singleness and directness and positive efficiency. To have half the people behind the times and the other half ahead of the times may be good education for progress, but it can not effect it. Sooner or later the people as a whole must become single-minded and be mobilized to the appropriate purpose of their day.

To-day our ghost-seeing reactionaries and our not less extravagant and abnormal visionaries certainly need at last to realize not that by the time-register this is the twentieth century, since they are all over-complacent with such a large round number and its three ciphers, but that the twentieth century really means something specific and exacting. Through some agency of liaison they must get together and give full and honest heed to the facts and values of the time they have inherited, to the visible attainments of mankind and to the real, however still latent, opportunities of the present life. All must give up the peculiar excitement of living at once in opposing groups and out of date and try the greater ex-

citement of being open and active contemporaries and really on time.

Surprising how hard it sometimes is actually to live in and of one's own time! How hard, and how worth while! The old ways tempt some, the established and privileged. Protest, attack and destruction occupy others who are suppressed and discontented and who will have their hopes and dreams. But timely action is worth while for all.

II

So, once more: What time is it? Twentieth century of the Christian Era, the watchman has called. Did he add that all was well? I failed to hear quite that. Disturbances in the market-place or down that side street may have confused things a bit. Perhaps all is not quite well. But, apart from the mere counting, what means this twentieth century?

With some of us seven-thirty means breakfast and the pleasant aroma of coffee. Other times of the day also have just such specific meanings. In the evening eight may mean an interesting book or perhaps for some the glare of the movies. But the present century? This is not so easy and the answer I shall give may quite lack aroma or glare or anything to hold attention. Thus, if at once I may leave the shallow waters, in ways which I propose to consider at some length and which in spite of possible difficulties I hope to make more interesting than any momentary aroma or glare, the twentieth century of the Christian Era means: (1) Anthropology, including especially psychology and implying generally man and his nature studied scientifically and exposed very intimately; (2) technology, including especially artifacture—instead of manufacture—often to the point of automatic machinery, man's burden of work taken off his shoulders and carried in ever-increasing amount mechanically; and so (3) new and great adventure. A date, I believe, hour or century, always means adventure! In those ways, then, our century would seem to have made a date with us. Are we going to keep it? Have we the courage of the adventure? There is the challenge.

With all my warning and preparation my grandly "ological" way of tolling out the century may only puzzle. This I can not help. All know that these are days of amazing and amazingly large things, taxing the understanding at every turn. But a short time ago we were measuring things in hundreds and thousands; to-day, with effort, in billions. Every thing is big, very big, except the world, and this somehow the big things have made small, very small. Civilization has reached so far as no longer—except at far

north or far south—to have a frontier. History has gone back even beyond the prehistoric. Must occupy us, then, however puzzling, however "ological" or in any way grandiloquent, really large ideas and comprehensive standpoints. To-day, if ever, one has a right to ask that people accommodate their mind's eyes to large views. Mere technical philosophy may not be a crying need of the hour; but, whatever the effort required, at least fundamental ideas are. Long enough have we been meeting our various problems of life in conventional and superficial ways; direct, frontal attacks have had their day, including certain years of war and the long impatient years since; demanded now the flank movement of getting behind the lines or beneath the surface, which only comprehensive ideas can possibly effect. So, while many may still wish to toll the present century with more sound than sense, I must hold to my 'ologies.

These 'ologies I shall discuss in order as the large, important events of the day, anthropology and technology; and then, thirdly, I shall try to indicate the new and great adventure of our time.

III

In the first place, then, ours is an era of anthropology, the intimate naturalistic and scientific study of man. The great intimacy of the science is best seen in its two very significant branches, psychology and psychiatry, now natural sciences.

You and I are accustomed to this science even in its more intimate forms. Many of us, however, may never have appreciated all of its implications and in particular its significance historically. On the whole until about forty years ago man was protected from the intruding intimacies of science. In respect to what distinguished him from things and other creatures he was an object of interest theologically, morally, even abstractly and rationalistically, but not scientifically and naturalistically. Persons born since 1900 may have to think twice before they will at all appreciate the change that has taken place. Now the intimate anthropological science of psychology is in the company of the natural sciences. In Ann Arbor we have what in spite of the passing of the years we still call the "New Science Building." It contains the laboratories, class-rooms and special libraries of four natural sciences: Geology, botany, zoology and psychology. This very series suggests a sort of advance of natural science on man. But the newness of our building might be taken as referring, not just to the building, but to the inclusion of psychology. Fledgling from the warm, human nest of mental and moral philosophy, psychology has run off to the very different habitat of natural science. How the excellent Noah Porter, D.D., author of the once widely used

"Human Intellect" (1868), "Science of Nature vs. The Science of Man" (1881) and "Moral Science" (1885) would scurry to the bank of the pond of science and frantically call on psychology to come back to dry land and spiritual safety. No clamor on the bank, however, can bring the lively and ever stronger science back. Psychiatry and psycho-analysis have been added to its activity, as if diving to swimming, and, while time must pass before the new science and its applications to life will be clearly realized, the event has taken place and stands out as something of great importance to be faced and appraised. Some years hence the historians will be chronicling how such close, scientific study of man happened. The narrative of one of them we may read in imagination even now:

It is peculiarly interesting to record that in the later nineteenth and earlier twentieth century there were those who discovered with a completeness not before supposed possible most intimate correlations between the body and the mind of man and, as even more noteworthy, who succeeded in applying the methods of natural and experimental science not merely to the study of man in his physiological character but also to the study of his consciousness, of his knowledge and will and feeling. At the universities laboratories for such study sprang up almost like mushrooms. Journals of physiological, genetic, comparative and experimental psychology, as well as of many other phases of scientific anthropological inquiry, were published. In a word the study of man, long in large measure theological or with the waning of theology only abstractly rationalistic, came to be most closely associated with the natural sciences and it appeared as if man's long persistent aloofness from nature had been abandoned. The effect on his institutions, on the conduct of his life politically and economically, socially and morally, was of course tremendous, but was not fully appreciated for some time.

So runs a part of that future record. Several pages further on I have found also this interesting comment:

The movement for an unreserved scientific anthropology, notably rapid and successful in America, at first seemed to supply valuable fuel for the fires of materialism and fatalism, but in the end actually proved to be a source of real incentive and opportunity to mankind and so of distinct spiritual progress. Can truth, however disturbing at first, ever have any other outcome?

The fact or event, then, of our time being what we have so recorded for us, what fully and exactly does it mean? To understand it fully and properly, we must of course face it candidly, the intimacy and exposure, the realism and apparent materialism of it; but especially must we take clearly into account the history, the long history, by which it has come about. Some overlook this history or even deliberately turn their backs on it. How blind they are or how foolish so to betray a great heritage. Their folly must not be ours. Some years ago I was at luncheon with a gentleman

of great artistic interest and sensibility, a virtuoso superlatively. I ventured to comment on the color, specially fine and intriguing, of the walls of his dining-room.

"Yes," he said, "it certainly is unusual. What is more, I have peculiar satisfaction in it. I took great pains to get it. On these walls my decorator put twenty coats."

"Surely," I exclaimed, "there was some experimenting, some waste."

"Experimenting, yes; but no waste. I feel, as I look, that every one of the twenty coats, even the first, is present in what you and I see now."

He had a more sensitive eye than I. His claim, however, must help us to comprehend why our own time, just to appraise itself, must know fully its past. You and I may not be up to date, we may not really qualify as our own true contemporaries, unless we actually sense or catch the contributing, however now hidden, traditions of a long history in what we now behold or now do. Our anthropological, often intimately psychological interest, methodical and naturalistic and scientific in its expression, is indeed late come and it is what it is, unique, *sui generis,* but we must remember that necessarily it is the product, as it were, a latest coat made subtle by many others before it, of nearly twenty centuries of preparation. Duly appraised, this present is a great memory. So knowledge of the earlier coats and of the progressive and dramatic order of them is necessary if we would know the last and would appreciate the new life that in our own time this last coat either has made already or is to make possible.

"Was there one for each century?" I hear some worried person ask. Possibly. But I shall shorten the whole record to four.

IV

In four single words hear the record of Christendom's history: Theology, mechanics, biology and to-day's anthropology.

"Mere jargon of some cloister," says some one; "Why haven't we by this time outgrown the cloister? Mere language of an academic curriculum." The charge is true. May every age have its cloister or its "classic shades!" In those four words lies an important human story for him who will give attention. Do you see nothing in their given order? The gradual breaking down of man's reserve and aloofness from nature? Do you fail to see the successive standpoints and key-ideas that have made our history not merely intellectually but also in the important practical affairs of morals, politics and economics? Do but consider:

First, theology in the Middle Ages, regulating life narrowly and

dogmatically through the aloofness of a theocratic, doctrinal and legalistic institution, Christendom's first device for law and order, for system or mechanism, directly man-powered and militaristic, the medieval church, an institution of morals, politics and economics all in one and all aloof and as supernatural as unnatural.

Next, in the seventeenth and eighteenth centuries, solar mechanics and mathematics with regulation of life from the nearer sun, a distant but at least no longer invisible and supernatural source, with a temporal and secular natural institution, the state, claiming at least equality when not superiority to the church, appropriating the church's methods of regulation and insisting at least on temporal power as its peculiar prerogative, and with a distinct regard to reason as native to man and to law as natural.

Then, in the nineteenth century, man come still nearer nature, biology, revealing a unity and a certain essential orderliness of all life and by these and the special hypothesis of evolution bringing man and the natural world not yet completely but still more closely together, enriching the great idea of nature's mechanical or, as it was in spirit, institutional order with the even greater idea of the living organism, wherein mechanism became versatile, adaptive, even supermechanical, and under influence of which among other effects, monarchical absolutism and rigidity gave way to the orderly adaptability, the organic movement of democracy. The practical effects, generally known and appreciated, of biology and evolution on actual life have certainly been no greater, for their time, no more momentous, than were those of the mechanics in the previous era.

And to-day, lastly, aloofness and reservations apparently quite gone, anthropology and psychology candidly naturalistic and scientific and in their directness and candor also bound in momentous ways to affect our practical life of affairs, giving us what in the language of the movies might be called nature's own "close-up," even an exposure, as intimate as natural, perhaps as offensive as good for the soul of man.

How aloof was man at first, presuming to live aside from nature and always in view of the yonder and hereafter. Now, not just formally or mechanically, as for a time, nor yet only biologically, the somewhat closer way which followed, but most intimately, in the very intimacy of his consciousness and reason, of his passion and will, how one with nature he is being made to appear!

Does any one still find in that quaternion—theology, solar mechanics, evolutional biology and intimate anthropology—only a catalogue of names for scholastic learning? Does any one still fail to catch the story, the great dramatic story, whose eras it recites?

At risk of being wearisome with what may be a needless elaboration, I am going to indicate the motive and character of the story in several ways as follows. Thus, most obviously and almost repetitiously on my part, it shows Christendom in process of a gradual adaptation to the natural environment; then it shows important expansion and liberation, the spirit of life repeatedly breaking away from an established order or letter; and, finally, it shows moral experience and growth involving frequent struggle and disaster but also continued attainments. When these aspects of the story of Christendom have been made clear, we ought to be able to understand the particular mark of our own time, with which we are now so concerned, our present scientific anthropology and the implications and memories which enrich it.

V

The medieval theology and its aloof institution hardly suggest even in possibility or preparation anything like adaptation to the natural environment. Yet, with no intent of disrespect in my secular terms, the medieval church may well be looked upon as a strategical retreat on man's part. Let us call it that, then, and allow a change of the metaphor in a moment. In those troublous times, when the structures and instruments of the pre-Christian civilizations had scarcely one stone left upon another, one part in orderly relation to its neighbor, man met the disorder, the intellectual and moral and political chaos, with the excellent device of a super-mundane supernatural institution, St. Augustine's "City of God." Into that he withdrew, taking for preservation what treasures of the past he could take, things and memories. The long threatening storms raged. "The rain was upon the earth forty days and forty nights." The floods rose. Like the Ark of old, the Church rode the storm, saving man and his past and with disciplines, with mental and spiritual exercises of all sorts preparing him for the future. Time came, when the protected life within could once more go out on dry land and in more direct and positive way undertake to solve the problems of the disturbed environment. There was, of course, a significant clearing of the sky and subsiding of the violence, when Galileo—as the dove bringing the olive leaf!—discovered the orderly heavens and in general, with Newton in good time adding evidence, the dependable mechanism of physical nature. Personally, I have often wondered if those discoveries of the astronomers had ever been made without just such a preparatory discipline of mind and character as the Church had provided. Say what one will, in the long run only orderly and controlled persons can reason within themselves or find convincing law and order in the world around them.

From Galileo's time on man had and showed more confidence of earth, feeling more at home and by all sorts of ingenious mechanical applications gaining an ever increasing and widening mastery of earth, safely exploring all the seas, exploring, settling and exploiting the continents, possessing first the earth's surface, then its more intimate resources. The biology and then the anthropology and psychology that followed the earlier mechanics only served to carry forward the adaptation and this came at last to be, as some one is sure to say, thinking doubtless of Freud and other very scientific psychoanalysts, adaptation to the point of hopeless loss of the human self in the natural, in the material and sensuous if not sensual, so that even the term "close-up," suggested already, would seem hardly adequate.

The historic "illumination" and exposure of selfish and sensuous human nature in the eighteenth century was but a candle flame or a smoking torch compared with the electric light and X-ray of present analyses and revelations of man's very soul. Of that earlier exposure writes one historian:[2] "There was nothing left but matter —a wholly unspiritualized mass. Sensuous greeds and needs on all sides! Individuality, grossest self-seeking, the law!" Witness "the licentiousness of the miserable court which demanded slavish obedience," the "tyranny and hypocrisy of a priesthood rotten to the core" and an "administration of the state, a dispensation of justice, a condition of society, that must revolt to the utmost every intellectual principle and every moral feeling of man." But to-day, so far has man's naturalization gone, as now registered not just by a historian but by scientists, even soul itself is sex or, as a bit better, nutrition and sex. Could naturalism and its exposure go farther? With some success, too, those who see the adaptation as ending in a complete surrender to physical nature may press their case. Yet, so much granted, the whole truth can not be told so. Facing the unquestionable physical naturalism of the time, I find myself somehow reassured when I reflect that such a sensuous realism, while never without its dangers, has not always been in bad company. Early and evangelical Christianity, at least after St, Augustine, certainly has even cultivated a very distinct sensuous and physical realism. Witness so much in the vocabulary of orthodox Christianity. Possibly our own present realism and materialism, culmination of Christendom's gradual adaptation to the natural environment, has its own spiritual meaning and purpose.

Nor, having said so much, can I refrain from saying more. It must have some important bearing on the full meaning of the adap-

[2] Schwegler in his "History of Philosophy," translated by J. H. Stirling, p. 188.

tive process with its interesting successive eras and its present outcome that in the minds and hearts of men God seems to have had a way of always identifying himself with the sphere of life which at any particular stage man has recognized. He has followed the accepted law and order. With Galileo's science and its discoveries, for example, God actually left the traditional church and, if the mystical and nature-loving saints or the pantheists generally, whether religious or philosophical, may give testimony, reappeared as the spirit or genius, the presiding ruler, of the new system. With Darwin, again, and the evidences of evolution, there came to expression a still broader and deeper pantheism; God was so expanded as to be identified with or declared immanent in the great unity of all life. So, by the history of Christendom's growing pantheism, God has kept company with man through the long process by which man has been finding himself in nature and even the extreme naturalism of our day may not be as hopelessly unspiritual as some regard it. To speak now only as a historian, whatever may have been man's attitude, God at least has shown no fear of following the truth.

VI

Expansion and liberation also were said to be marks of the progress of Christendom. The expansive theism, or pantheism, by which God became ever more and more a free and comprehensive spirit, less and less a locally and officially residing and presiding deity, ruling life from outside and above, we have already remarked. But, this aside, in the life of Christendom, now under one formal order or system, now under another and broader, there appear to have been certain critical times, closely corresponding to the eras which have been indicated, when to all intents and purposes, as his experience has enlarged, man has heard and eventually has heeded the cry of an expanding and freeing life. "No longer the narrow and formal letter, but the more vital, the more open and at same time deeper spirit." Surely something of that sort must always accompany adaptation. Successful adaptation must be quite impossible without plasticity and to secure this an old habit or system of life, in short the letter that killeth must constantly yield to the spirit that setteth free: St. Augustine's narrow institution, for example, of the middle ages, exclusive and aloof, to Galileo's or Newton's broad and more efficient helio-centric mechanism of nature; nature's mere physical mechanism, again, to Darwin's still more plastic or versatile and adaptive organism; and this, as the years pass and still another order cometh, to the modern psychologist's also natural but still freer conscious and willing individual. Just to be

able to see in these changes not violent revolutions but expansion and liberation of the spirit, in other words to see them as enlargement and fulfilment, not betrayal, of the cherished past is helpful in many ways and here particularly with respect to finding the past and its memories, however long removed and however refined by generalization, in a present that many are finding strange and offensive.

Words, words, words! Theology, mechanics, biology and anthropology over and over again! Institution, mechanism, organism and natural but conscious individual! Why not tell of changing political institutions, economic development and moral and spiritual growth? Why not speak out of a life of actual affairs? What are "adaptation to environment" and "liberation of the spirit" compared with actual exploration and occupation and exploitation of the earth, with wars and battles, with diplomatic as well as military triumphs, with royal splendors or tragic martyrdoms, with epoch-making inventions overcoming space and time, with expanding commerce and industry, with all kinds of "broadcasting," with a whole world of isolated localities become, as many have been calling it in effect, if not always in recognized form, a single community politically and economically and morally, suggesting such a social unit as the Greek city-state or the church of St. Paul, "members one of another"? What indeed are they if not the same thing! The histories of political and economic and moral conditions would all certainly show within each context adaptation and expansion and liberation of the spirit.

VII

Here, while still proceeding with our purpose, we may enjoy a little diversion, helpful especially to those who to a diet of 'ologies and other wordiness prefer concrete—I mean things that are concrete. Cruthers, I believe, in one of his essays has dubbed this the concrete age. It is that, although Cruthers did not get so far as to quote in evidence the modern psychologists and very realistic psychiatrists.

The life of Christendom was said to show, besides adaptation and liberation, moral experience and growth involving struggle and disaster but also attainment or arrival. I propose, then, to explain this by telling a very simple story—for the concrete-minded. A story, even when as true as this I am to tell, may be not without pleasant relief for everybody. Only now I would that some twentieth century John Bunyan would take up the narrative for me. I can merely indicate the opportunity that certainly awaits some capable raconteur.

Well over nineteen hundred years ago Christian set out on his

long and arduous journey through the centuries and no ordinary journey has been his. Adventure after adventure befell him as he passed from one country to another, from one outlook on the world to another. Over and over again body and mind and character were assailed. With every discovered opportunity came danger, often extreme disaster. Suffering was his portion with every real accomplishment. We of to-day in our own despair, seeing misery in so many parts of the world, complacent prosperity and inaction, our post-bellum pacifism, in other parts, might well take courage from his example. So often he fell prostrate and it was as if he would never rise. As often he was seen again up and on his way. Were I speaking in dream or allegory I might tell of meetings with Pliable and Timorous and Mistrust, with Ignorance and Blindman, Violence and Love-Lust, with Breed-Hate and See-Red, with Faith also and Knowledge, with Persistence and Do-Well and Never-Die, and with many others, some delaying and misleading, some instructing him wisely, inspiring him with new vision and setting him on his forward way. My tale, however, is no such imaginary one, albeit skilful fiction might better serve my present purpose. Real characters were met by Christian, well-known kings and emperors, popes, great soldiers, bankers, artists, thinkers—such as St. Augustine, Galileo, Darwin, William James—and leaders of all kinds. In each group, I may go so far as to say, some were followers of On-Mischief-Bent, some of Do-Right and Know-the-Truth and not always did Christian keep the better company. Whenever new vision came to him and new adventure opened he always found himself between license and freedom and, as we to-day can well understand, was hard beset to know the real difference, often mistaking one for the other. He came, for a conspicuous example, to the time of the brilliant, over-lighted Renaissance, a tragic time for him morally, a tense one intellectually, as potent with danger as with hopeful adventure. I have often to wonder how he ever survived. Most corrupt popes and Macchiavellian princes were against him. Cunning intellectuals bewildered him. Cynical candor assailed the faith and courage that had been his. A sensuous literature intrigued him. Still, at one time helped by reading Dante's story of the development of a human soul and his beautiful sublimation of romantic love and at another, when in despair he had stopped in one of the great churches, hoping for quiet if not for real support, by a glimpse of fair nature through an opened window, and, again, inspired by Galileo's heavens that anew declared the glory of God, he did manage in each instance to take up his pilgrimage and proceed on his forward way. Then, near the very end of his journey, which apparently could not be very far from our own time, his plight was once more a sorry one, far sorrier indeed than it had ever been before. Break-Things tempted him. Be-Normal and

Stop-Thinking—here I have to be allegorical—actually bound him for a time hand and foot. But, whether with good warrant I shall not try to say, he did gain hope and determination for real freedom and progress from his memories of the deliverances which had been his so many times before.

There is a dramatic story for some skilful narrator. But enough now if you see in Christendom's journey through the centuries, not a mere ordinary history of one thing or another, but a spiritual pilgrimage with adventure and abundant disaster yet with accomplishment also. A spiritual pilgrimage, I have said, and at once somebody may wonder. How may we speak of a spiritual pilgrimage, at all analogous with that recounted so wonderfully by Bunyan as "from this world to that which is to come," if the materialism, the naturalistic, scientific realism of our time be the goal at which Christendom has arrived? Bunyan's Christian journeyed from earth to heaven, but Christendom, our Christian, as theology has gradually given place to scientific anthropology and intimate psychology, has journeyed apparently from heaven to earth. The question, then, is a fair one, as fair as natural, and of course it only brings back our persistent problem, the problem of the last coat: Is anything of Christendom's great past left? Is there anything spiritual, is there any spiritual gain in the sensuous realism of our day? In reply I only repeat from above that such realism has not always been in bad company. In due time it may be possible to say more. Suffice it now that Bunyan himself, as Christian enters heaven, has much to tell of the white robes of the angels, the shining glory, the sweetly ringing bells and wondrous music, the harps and crowns, and the real and sensuous magnificence generally. There was realism in very truth. With all that sensuous and realistic magnificence, too, with the glare of gold and the wondrous music I somehow have to connect the words with which the seventeenth century narrator woke from his dream:

"Then I saw that there was a way to hell even from the gates of heaven."

That, however, is another side of the story and I conclude my immediate reply to the questioner by indulging in a glittering and rather pious generality. For any one with a real faith truth can be the only way of life and heaven only a name for reality as the truth may reveal it. After all, for good or for ill, nothing can shine like reality and the shining realism of our day, the gold and the music, the sensuous reality generally, whether presenting heaven or revealing a way to hell, could hardly be expected to be such as Bunyan knew three centuries ago.

(To be concluded)

INFLUENZA AND THE WEATHER IN THE UNITED STATES IN 1918[1]

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Aside from the Great War the influenza epidemic of 1918 was perhaps the most terrible calamity that has afflicted the world since the Black Death of the fourteenth century. The main epidemic has, as usual, been followed by minor epidemics, first a few months later, and then in each succeeding winter. There is real ground for the fear expressed by Sir Ronald Ross, the famous student of tropical diseases, that if influenza continues unchecked it may ultimately harm northern countries as much as malaria harms those of lower latitudes.

In studying influenza two of the important questions which confront the investigator are: Why does the disease break out so suddenly at certain times? Why does it vary so much from city to city?

As to the first question, no conclusive answer is yet available. Apparently, something occasionally stimulates the bacteria which cause influenza, and then for a few weeks or years they acquire extraordinary virulence. The stimulus may be in the external environment; or perchance all living organisms have fundamental physiological rhythms which cause them alternately to be strong and weak. The variations in virulence may possibly be due to changes in man's power of resistance. People may become susceptible to the disease because of their environment, or because between one main epidemic and the next there is time for them to lose whatever immunity they have acquired through having the disease or through carrying its germs, even though the germs never produce illness. Another possibility is that the severity of epidemics depends in part on the accidental coincidence of the rhythms of two or more kinds of bacteria. Still other possibilities might be mentioned. Many students are studying the problem, and some day we shall have a solution. As yet, however, we do not know what stimulates the influenza bacteria to pernicious activity; and hence we have no means of knowing when a new epidemic will appear or of estimating how severe it will be when once it has stricken us.

Concerning the variations in epidemics from place to place, we

[1] Based on the work of the *Committee on the Atmosphere and Man* of the National Research Council, a full report of which is published by the council.

know, for example, that during ten weeks at the time of the main epidemic of 1918 Philadelphia had a death rate from influenza and the resultant pneumonia four times as large as that of Milwaukee. The death rate in Pittsburgh was twice as great as in the neighboring and similar city of Cleveland. Till recently, however, we have had no conclusive evidence as to why such enormous variations take place from city to city. Certain new and important possibilities, however, have now been opened up by the work of Professor Raymond Pearl of the School of Hygiene and Public Health at The Johns Hopkins University and by the subsequent investigations of a Committee on the Atmosphere and Man appointed by the National Research Council. These investigators have compared the destructiveness of the influenza epidemic of 1918 in the large cities of the United States with the following factors:

A. Factors of human environment (demography).
   1. Age distribution of the population, that is, the relative number of inhabitants of various ages.
   2. Ratio of the sexes, that is, the number of females for every hundred males.
   3. Density of the population (number of persons per acre within the city limits).
   4. Rate of growth from 1900 to 1910.

B. Factors of geographical position.
   5. Distance from Boston where the epidemic began.
   6. Longitude.
   7. Latitude.

C. Physiological factors represented by the following normal death rates in 1915, 1916 and 1917.
   8. All causes.
   9. Pulmonary tuberculosis.
   10. Organic diseases of the heart.
   11. Nephritis and acute Bright's disease.
   12. Typhoid fever.
   13. Cancer and other malignant tumors.

D. Racial factors.
   14. Percentage of negroes, 1920.
   15. Percentage of foreign born, 1920.

E. Industrial factor.
   16. Percentage of population engaged in manufacturing, 1919.

F. Climatic factors.
   17. Mean temperature for day and night.
   18. Change of mean temperature from one day to the next.
   19. Absolute humidity, or actual weight of water vapor per cubic foot of space.
   20. Relative humidity, or percentage of possible water vapor.
   21. Weather—a combination of Nos. 17–20.
   22. Climatic energy—the energy or vigor that the general climate would be expected to give on the basis of the measured work done by factory operatives and students under different weather conditions.

Directly or indirectly these 22 factors embrace most of the conditions which may have been effective in causing people's power of resistance to the epidemic to vary from city to city. Sanitation and medical practice, however, fail to appear in the list because their degree of excellence can not easily be expressed in figures. But the death rate from typhoid fever is generally supposed to be an unusually good measure of sanitary efficiency, while other death rates are in most places a fairly good index of the excellence of the medical service. Almost the only important fields which the factors do not cover is that of variations in the disease-bringing bacteria so far as such variations are due to causes not included in our table. When all these various factors are investigated by means of the most exact and delicate mathematical method yet known, the only one which shows any conclusive causal relation to the destructiveness of this particular epidemic is the weather.

Let us review the steps by which this surprising conclusion has been reached. The method which has been employed is one of the great triumphs of mathematics. It is called partial or net correlation. The labor involved in this method is most arduous, but the results, when it is properly used, are beautifully clear and simple. The gist of the matter is that a complex phenomenon like variations in the death rate from influenza may be due in part to any one of many causes. Only to a very limited degree can we experiment to see which causes are effective, for man is too precious to be sacrificed lightly. Yet if we are to discover how to prevent or mitigate future epidemics, it is essential to obtain the facts which could be discovered by experiments. The essence of such experiments is that one of the conditions which may cause the differences should be allowed to vary, while the rest are kept constant. The observed variations in the death rate can then be easily compared with the variations in the condition which the experimenter is investigating. The method of partial correlation acts like such an experiment. It allows the mathematician to determine the effect that any one condition would have if all the others were kept constant. An illustration will make the matter clear.

Suppose that you wish to know what conditions really determine the speed at which you drive your automobile. You can try experiments, or you can keep for each mile a record of the conditions that are presumably important, including (1) number of minutes per mile; (2) roughness of the road on a scale from 1, very smooth, to 10, very rough; (3) number of vehicles per hundred square feet of roadway, which is more important than per hundred linear foot; (4) number of traffic policemen; (5) number of cross streets; (6) size of the city or town in which lies the given mile of road; and (7) width of the road.

At first thought one is inclined to say that the time per mile is increased by each of the other conditions mentioned above except wide roads. Partial correlations will show that this is not true. A rough road and the presence of many vehicles do, indeed, always tend to increase the time per mile. But if you are absolutely positive that there is no traffic either on your road or on the cross streets, if there are no traffic policemen, and if the road is smooth and wide, you drive as fast where there are many cross streets as where there are few. The size of the cities and towns is equally ineffective. You drive as slowly in the center of Rochester as in the center of New York, even though New York is nearly twenty times as large. That the size of the city is not in itself a determinant of your speed you can judge by driving through the streets of a big city and a little one at three o'clock in the morning. You go as fast in the big city as in the other, provided all the other conditions are kept constant.

But surely the wider the road the greater the speed. No, for city streets are almost invariably wider than the paved part of state roads out in the country. Yet on the narrow country road you drive thirty miles an hour with safety, whereas on the wide city street you often go no more than ten. If there were no traffic and no cross streets, you would not care whether the roadway was wide or narrow.

How about the policeman? Does he slow you up? Analyze your data by means of partial correlations. You will find that what chiefly checks you in the vicinity of policemen is the cross streets and the traffic, but the cross streets are important only because they carry traffic. If there is no one on the road, the policeman signals to you far away, and you pass the crossing almost without slowing down; if the traffic is heavy, the policeman prevents it from getting tied up. In the long run the policeman actually causes you to make better time than you could if he were not there. An analysis of your data by the method of partial correlation would be as conclusive as a series of experiments in showing that the really important factors are first, the roughness of the road and the number of vehicles per hundred square feet, both of which cut down your speed as they become more pronounced; and second, the policemen who increase your speed as well as your safety. The cross streets, the size of the towns, and the width of the road assume importance only through their relation to the volume of traffic.

By means of this precise mathematical method Professor Raymond Pearl of Johns Hopkins University has compared certain environmental conditions with the destructiveness of the influenza epidemic in 34 large cities of the United States. The first number in each line of Table II is the correlation coefficient between the

destructiveness of the epidemic during a period of 25 weeks and the condition named in that line, all the other conditions in the table being held constant. The second figure in each line shows the ratio between the correlation coefficient and its probable error. If this second figure is between three and four it suggests a relationship; if it rises as high as four it probably indicates a real relationship but does not prove it; while if it is more than six, the reality of the relationship is established almost beyond doubt, provided the method is applied correctly. A relationship, however, does not mean that one condition is the direct cause of the other, but merely that they vary together and would give a fairly large correlation coefficient. But if partial correlations are applied and the number of vehicles is held constant, the coefficient for size would fall to less than four times the probable error. We shall see that there is a similar fall in the apparent but illusory relation of the epidemic to latitude and to the death rates from all causes and from heart diseases.

TABLE I

Partial Correlation Coefficients between Death Rates from Influenza and Pneumonia for Ten Weeks in 1918 and each of six Environmental Conditions, when the other five Environmental Conditions are held constant

	Coefficient	Ratio of Coefficient to Probable Error
(1) Age distribution of population	0.132	1.2
(2) Sex ratio of population	0.161	1.4
(3) Density of population per acre	0.163	1.4
(4) Latitude of city	*—0.424*	*4.5*
(5) Longitude of city	—0.133	1.2
(6) Rate of growth, 1900 to 1910	—0.083	0.7

On the basis of this table, as Dr. Pearl puts it: "It can be safely asserted that in the determination of the variation among these 34 large American cities in respect to the excess mortality due to the epidemic, the age and sex distribution of the population, its degree of crowding, its rate of recent growth, and its distance west from the Atlantic seaboard played no appreciable part whatever." Latitude, on the other hand, seems in this table to play a significant part. The minus sign of its coefficient means that low latitude was associated with a high death rate. But latitude can affect people's health only through climate, or through some other condition which is influenced by climate. Professors Winslow and Grove have shown that the normal death rate is the factor through which latitude and climate appear to be related to the epidemic, for when the normal death rate is held constant, the apparent effect of latitude disappears.

Having found no cause for geographical variations in influenza

along these environmental lines, let us consider another set of correlations carried out by Professor Pearl. In Table III the destructiveness of the epidemic is correlated with each of several normal death rates, while the others are held constant.

TABLE II

Partial Correlation Coefficients between the Death Rate from Influenza and Pneumonia for Ten Weeks in 1918 and Six Normal Death Rates from Various Causes, When the Other Five Normal Death Rates are held constant

	Coefficient	Ratio of Coefficient to Probable Error
(1) Death rate from all causes	*0.405*	*4.2*
(2) Death rate from pulmonary tuberculosis	0.279	2.6
(3) Death rate from organic diseases of the heart	*0.537*	*6.6*
(4) Death rate from nephritis and acute Bright's disease	—0.008	0.1
(5) Death rate from typhoid fever	—0.138	1.2
(6) Death rate from cancer and other malignant tumors	0.268	2.5

Here, as in the other table, it is clear that most of the normal death rates had nothing to do with the severity of the epidemic. The popular view that the presence of tuberculosis rendered a population especially liable to the epidemic is shown to be false by the fact that the ratio at the end of line 2 is only 2.6, too small to be significant. If the popular view were true, New Orleans, Cincinnati and Baltimore would have been especially great sufferers from the epidemic, while Grand Rapids, Milwaukee and Rochester would have suffered least. As a matter of fact, Pittsburgh, Nashville and San Francisco had the highest mortality from the epidemic during the whole of the winter of 1918–1919, and Grand Rapids, Toledo and Indianapolis the lowest. In the same way, if the death rate from typhoid fever is as good an index of sanitary conditions as is generally supposed, the low figures in line 5 "bear out in precise mathematical terms what was obvious to the thoughtful and candid observer at the time of the epidemic, namely, that the severity with which a city was hit by the epidemic bore no relation to its general sanitary status or to the efficiency of its health organization." (Pearl). During the normal years, 1915, 1916 and 1917, Nashville, New Orleans and Atlanta showed the worst record from typhoid, while the best places were Cambridge, Boston and Chicago, all of which, and especially Boston, were very hard hit by the influenza.

On the other hand, the large figures in lines 1 and 3 suggest that where the death rate from all causes is normally high, as in

New Orleans, Albany and Baltimore, and especially where the population is especially liable to organic diseases of the heart, as in San Francisco, Washington, Albany and Boston, the influenza epidemic tended to be unusually fatal. Does this mean that in such places the population has some peculiar physiological characteristics whch render people susceptible to disease and especially to heart disease? Or does it mean that where there is a high death rate, especially from heart disease, there also happened in the fall of 1918 to be some other condition which allowed the epidemic to be unusually severe? The only conditions not yet considered which seem likely to be of importance and for which data are available are the percentages of foreign born, colored and factory workers in the population, the climate and the weather. All but the last of these are eliminated as soon as partial correlation coefficients are applied.

TABLE III

Correlation Ratios between Death Rate from Influenza Epidemic and Various Weather Conditions

I Days before or after onset of epidemic	II Temperature	III Change of temperature from one day to next	IV Absolute humidity	V Relative humidity
70–61 before	1.0	4.2[2]	2.0	1.5[2]
60–51 "	0.9	1.7[2]	3.6	3.5[2]
50–41 "	1.6	2.9[2]	3.6	2.9[2]
40–31 "	2.2	1.5[2]	1.6	1.1[2]
30–21 "	*6.6*[2]	—0.6[2]	*8.0*	1.9[2]
20–11 "	*6.8*[2]	—1.1[2]	*10.4*	—0.4[2]
10–1 "	*4.8*[2]	—0.6[2]	*7.0*	*5.5*[2]
0–9 after	1.4	—*5.3*[2]	1.5	1.1[2]
10–19 "	1.4	3.6[2]	1.9	1.7[2]
20–29 "	2.6	—0.5[2]	2.7	—0.8[2]
30–39 "	*8.1*	—0.6[2]	*6.9*	—0.1[2]
40–49 "	3.4	0.5[2]	4.0	—0.7[2]

There remains, then, only the weather. In order to test its effect the Committee on Atmosphere and Man carried out a further investigation. For 36 large cities in the United States they took the death rate from influenza and pneumonia during the ten weeks succeeding the outbreak of the epidemic in each city. These ten weeks cover the first and in most places much the more important out-

[2] Full data are available for only 32 cities, but for four cities the weather data for neighboring cities have in some cases been used as indicated by the reference; namely, New York for Newark, Boston for Cambridge, St. Paul for Minneapolis, and Providence for Fall River. The results are practically the same whether 32 or 36 cities are employed.

break. The committee also obtained data as to the temperature, the relative humidity, the absolute humidity and the change of temperature from one day to the next. These weather data were tabulated for periods of ten days beginning 70 days before the onset of the epidemic and continuing 50 days thereafter. The results appear in Table IV where, for convenience, only the ratios between the correlation coefficients and their probable errors are given. A minus sign before the ratio means that the sign of the coefficient is negative, or in other words that when deaths from the epidemic were numerous the indicated weather condition tended to have a low value.

This table is full of interesting facts. Previous to the thirtieth day before the epidemic there is evidence of no strong relationship between any weather condition and the destructiveness of the influenza. During the 30 days just before the onset of the epidemic, however, the temperature and especially the absolute humidity show a strong relation to the succeeding death rate. This means that if the weather was warm during the month before the influenza reached a city, the death rate was high; if the amount of moisture in the air was great, the conditions were still worse. At Boston, for example, from the twentieth to the eleventh days before the epidemic the temperature was higher than during the corresponding period in any other cities except New Orleans, New York and Los Angeles. This was because the epidemic broke out in Boston earlier than anywhere else. In places like St. Paul, Toledo and Grand Rapids, where cool and fairly dry autumn weather prevailed for a month before the epidemic, it apparently gave people a certain degree of stored-up vigor which stood them in good stead and warded off the ravages of the disease. If the temperature was variable, as it was in Cleveland, Columbus and Richmond, and especially if it fell during the ten days after the onset of the epidemic, the death rate was lower than where the contrary conditions prevailed, as appears from the high negative coefficient in column III. On the other hand, high relative humidity and damp air during the ten days before the onset, as appears in Column V, were associated with a relatively high death rate. Cambridge, New Haven and New Orleans suffered most in this respect. Such conditions perhaps made it easy for the bacteria to be transmitted. Droplets of water in the air may act as carriers of the bacteria, or may preserve their virility.

From the tenth to the thirtieth days after the onset of the epidemic the virulence of the bacteria was apparently so great that the state of the weather made no difference in the death rate. The vigor stored up from a previous period of good weather, however,

was clearly of great value, but the immediate weather conditions were not able to overcome the sudden and sweeping character of the infection when once it was started. After the thirtieth day there came another change, and the figures in the columns for temperature and absolute humidity again rise high. This was the time when in most places the disease reached its maximum and began to decline. At that time cool and moderately dry weather once more was associated with a low death rate. This does not necessarily mean that cold weather is favorable at the time of an epidemic. In fact, quite the contrary may be the case, for very low temperature may be as bad as high. Labrador suffered greatly in the epidemic of 1918.

Let us now put all the conditions of weather together, and compare their relation to the epidemic with that of four other factors, namely, climate and the following normal death rates: from all causes, from organic diseases of the heart and from pulmonary tuberculosis. A figure for the weather has been obtained by making the sum of the squares of the departures of the four conditions in Table IV proportional to the square roots of their correlation coefficients with the epidemic during the time when they appear to have been effective. For climate we will use what I have called climatic energy, that is, the degree of activity, vigor and health which any given climate appears to impart. This has been estimated on the basis of the measured work done by factory operatives and students in different kinds of weather. The results of a comparison of each of these five factors with the destructiveness of the influenza, when the remaining factors are held constant and thereby eliminated, are given in Table IV.

TABLE IV

Partial Correlation Coefficients between Death Rate from Influenza and Pneumonia for Ten Weeks in 1918 and Five Variable Conditions which may have had an Effect on that Death Rate

	Coefficient	Ratio of Coefficient to Probable Error
Death rate from tuberculosis	— 0.099	0.9
Death rate from all causes	0.271	2.6
Death rate from heart diseases	0.306	3.0
Climate	0.202	1.9
Weather	*0.570*	*7.6*

The meaning of this table is clear. When the factors which have been supposed to cause the influenza to differ in severity from city to city are analyzed according to the method of partial correlations, only one proves to have any unequivocal connection with the matter. That one is the weather. In this particular epidemic the

most fortunate cities were those in which during the month before the onset of the disease and during its crisis the thermometer had fallen fairly low after the heat of summer, but not low enough so that people began to feel cold or to need regular fires in the furnace. Dry air when the bacteria were first spreading and a drop of temperature immediately thereafter seem also to have been helpful. Data from other countries seem to support this conclusion. At any rate, so far as statistics are available, they show that India, Mexico, South Africa and other countries with relatively warm relaxing weather at the time of the epidemic, had enormous death rates from influenza compared with those in the United States; while eastern and southern Europe with their more monotonous weather suffered much more than western Europe. The degree of progress among a people and their regard for the ordinary rules of sanitation doubtless played an important part. But that part is probably smaller in a violent epidemic than in most diseases, as we may judge from the fact that typhoid fever shows no relation to the destructiveness of the epidemic in the United States. All this does not shed light on the perplexing problem of how epidemics arise and how the bacteria can be prevented from attaining the sudden virulence which is the most puzzling factor of all great epidemics. But it does suggest the favorable conditions of the air were the greatest factor yet detected in helping the people of the cities of the United States to ward off the influenza in the fall of 1918.

NATURE AND ART

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CORRECT conceptions of nature and art, of their essential characteristics, the difference between them and their relations to each other are the foundation of a sound scientific social philosophy. Such conceptions are plainly necessary to a correct understanding of the function of mind in the cosmos, and to the perception and progressive realization of the possibilities of intelligent action in directing and accelerating the march of social events. I purpose to show, therefore, the scope of the world of nature and the world of art, the real distinction between them and how they are related, and to point out some of the social implications of such distinction and relation.

First, however, as to the meaning of the terms employed.

The word "nature" is used chiefly, of course, in two senses, First, it is employed to denote the sum total of all things. It is thus made to include art. In a well-known passage Shakespeare says,

> Nature is made better by no mean,
> But Nature makes that mean; so, over that Art
> Which, you say, adds to Nature, is an Art
> That Nature makes.

And again,

> . . . . this is an art
> Which does mend nature, change it rather, but
> The art itself is nature.[1]

This, of course, is not the sense in which we shall employ the term.

Secondly, it is often if not usually restricted in its application to the phenomena that are altogether independent of human intelligence, that are due to the operation of purely natural forces and subject only to purely natural laws; as, for instance, volcanic eruptions, earthquakes, storms, floods, ocean currents, tides, winds, cloud movements, the growth of plants and animals in a state of nature, etc., etc. It is in this restricted sense, with certain extensions to be seen later on, that we propose to use the word nature.

The word "art" is also used in more than one sense. In teleological parlance the deity is "The Great Artificer" and "The Author"

[1] "Winter's Tale," Act IV, Sc. 4, lines 89–97.

of all things. "All things were made by him, and without him was not anything made that was made." In this view, "all things are artificial, for nature is the art of God."[2] So the poet, Young, in "Night Thoughts" ("Night" IX, line 1267), declares, "the course of nature is the art of God"; and Pope proclaims, "All nature is but art unknown to thee,"[3] etc.

Again, the word "art" is employed as if it applied only to poetry, painting, music, sculpture, etc., the so-called "fine arts." This is, of course, a purely conventional, not the scientific, sense of the word. For it is obvious that it applies also to the handicrafts, the making of things by tools and machines, to agriculture, etc., that is, to the mechanical and industrial arts. Properly speaking, then, art includes all these forms of activity, and it is in this broad and inclusive sense that the word will be employed throughout this discussion.

To appreciate the full scope of art, however, we must note carefully the distinction between art and "the arts," or, preferably, between art and "an art."

An art is a combined and coordinated system of human (artificial) activities continuously pursued and resulting in the production of such commodities or the rendering of such services as may secure for it a social sanction. Obviously, many such activities never become an art. And yet, every art must have its beginning in an artificial phenomenon, and a true definition of art must be broad enough to include every phenomenon of this kind. We have defined it as "the endeavor to realize an idea, ideal or purpose through the conscious employment of means."[4]

Art, then, as we shall employ the term, embraces every form of action involving a conscious purpose and a means of achieving it. Nature and art taken together thus include the entire phenomenal world.

Considering nature, then, in the narrower sense of the word, and art in its broadest sense, what is the true distinction between them?

Professor Huxley suggested the distinction in a general way in a passage which reads:

> In the strict sense of the word "nature," it denotes the sum of the phenomenal world, of that which has been, and is, and will be; and society, like art, is therefore a part of nature. But it is convenient to distinguish those parts of nature in which man plays the part of immediate cause, as some thing apart; and, therefore, society, like art, is usefully to be considered as distinct from nature.[5]

[2] Sir Thomas Browne, "Religio Medici," Pt. XVI.

[3] Essay on Man, EP. I. L. 289.

[4] See "The Art of Education," New York, The Macmillan Co., 1912, p. 2.

[5] Huxley, T. H., "Evolution and Ethics," New York, 1911, p. 202.

But the distinction drawn by Professor Huxley is not, perhaps was not meant to be, altogether accurate. He introduces a third term, society, and writes as if society belonged neither to nature nor to art, whereas it belongs to both. For the purposes of this discussion the distinction must be more clearly stated.

To perceive the distinction between two complexities we reduce them to their simplest terms. To the two now under consideration, if anywhere, we may apply the principle *uno disce omnes*. Let us, then, by examining, first, a simple natural, and then a simple artificial, phenomenon, endeavor to see exactly what differentiates the one from the other. Take, say, the flow of a river through an undeveloped country. All will agree that this is a natural phenomenon. A form of matter, water, moves along in the line of least resistance in obedience to the natural law of gravitation, its course and windings being determined by the general topography of the country and the friction of the river on its bed and banks. Human effort and intelligence have absolutely nothing to do with it; it is purely a phenomenon of nature. Now, let us suppose the water of this river, or a part of it, to be diverted by causing it to pass through a ditch or a flume for the purpose of irrigating a field. We now have the same phenomenon with a difference, the difference consisting wholly in the introduction of a means, the ditch or flume, and a purpose, irrigation. The phenomenon has now become plainly artificial. A means and a purpose, then, added to or mixed with a natural phenomenon make it artificial. That is the sole difference between a natural and an artificial phenomenon, and, as the difference between two such phenomena is the difference between all, wé have here the true distinction between nature and art.

So far, the discussion is simple and elementary. But some further illustration may be necessary to make the distinction clear.

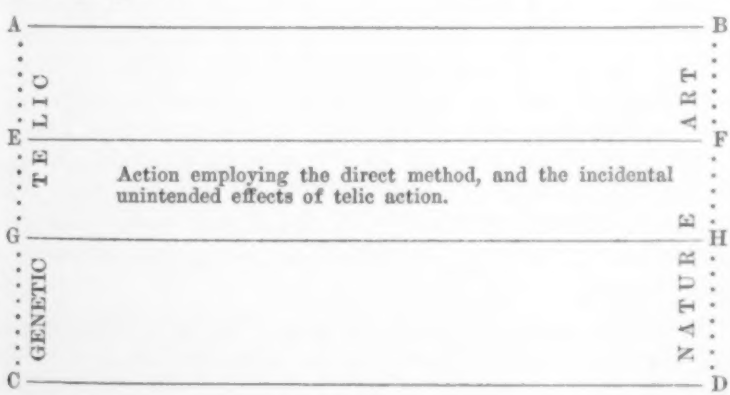
Suppose, then, that water is lifted from the river in the palm of the hand with the object of quenching the thirst. Here is an act involving means (the hand) and a purpose. Is it to be regarded as a part of nature or a part of art? That depends upon where we draw the line with respect to means. It must be arbitrarily drawn, for there are no exact lines of demarcation in this universe of infinitesimal gradations. Let us limit our conception of means, then, to things external to the organism or agent. In the case just cited no means is employed other than nature's means, that is, a part of the organism, the hand. Nothing mediates between the actor and the object, the force is directly applied. It is "direct action," and this direct method of conation is characteristic of nature. This act, then, must be regarded as belonging to nature.

Suppose, again, that in the endeavor to carry water through a ditch or flume in a settled country, some of it escapes and damages

somebody's property. What kind of phenomenon is that? It is a natural phenomenon, for intent or purpose is wanting. It is an incidental effect of purposive action, and belongs to the purely natural as much as if man had nothing whatever to do with it. What of the carrying of sand and gravel and depositing them upon the field to be irrigated? That, also, is a natural phenomenon and for the same reason, namely, the absence of purpose.

Nature, then, includes not only such phenomena as those with which man has nothing to do, but also all those phenomena that are due to his action but in which either of the two elements, means and purpose, is wanting; that is to say, all incidental and unintended results of man's action, and all purposeful actions performed by the direct method of conation. These two classes of phenomena cover a wide field. They include the major part of "social" phenomena.

Nature is self-active, and, as nature as a whole is regarded as a process of becoming, we say that natural phenomena are genetic, from the Greek verb **Γεηος,** whose root meaning is to become. Art, however, is always telic, (**Τελος**, end), that is, it is always aimed at something; it is purposive. But, as has just been shown, not all telic or purposive action belongs to art. From art must be excluded, generally speaking, all telic phenomena in which the direct method is employed; that is to say, the achievement of a purpose without the conscious employment of means. In other words the distinction between nature and art is not the same as the distinction between genetic and telic, or as that between nature and man, or nature and society. The exact scope of nature and art and the line of cleavage between them may be roughly suggested by the following figure.



Let the parallelogram A, B, C, D, represent the entire phenomenal world. We may then draw the lines G, H, to separate genetic from telic phenomena, and the line E, F, so as to include within the

rectangle E, F, G, H, those phenomena in which man plays a part, but which are either incidental to his purpose, or, while telic or purposive, are yet performed by the direct method, that is, without the conscious employment of means. The rectangle E, F, C, D, will then cover the realm of Nature, and that of A, B, E, F, the realm of Art. Presented in a diagram the matter will appear as follows:[6]

- Phenomena
  - Natural
    - Genetic
      - Spontaneous.
      - Incidental to telic action.
    - Telic, but employing the direct method of conation.
  - Artificial
    - Telic, employing the indirect method of conation.

The figure and diagram are, of course, somewhat misleading, for art and nature can not thus be so neatly separated. They are always found together. For, as Emerson said, while "nature in the common sense applies to essences unchanged by man, space, the air, the river, the leaf; art is applied to the mixture of his will with the same things, as in a house, a canal, a statue, a picture." Thus, art, he says, is "nature passed through the alembic of man."[7] But some such diagram may be an aid to the conceptions we have tried to set forth.

Now, as art always implies a means and a purpose, it is synonymous with intelligent action, and we may safely say that it lies wholly within the realm of conscious human action. Physical nature simulates art to some extent. It utilizes all the mechanical principles, save perhaps the wheel and axle. There are more or less authenticated instances of animal action that simulates art; the use of stones and clubs by some of the higher apes, for instance. The solitary wasp has been observed in the act of tamping the ground over its eggs with a small stone held in its mandibles. Ants, bees, beavers, etc., are said to "ply their arts." All such cases, however, should probably be relegated to instinct, and instinctive action is always a natural phenomenon, since it is action without a conscious purpose. At all events, we shall not be far from the truth if we regard art as belonging wholly to the human realm (not coextensive with it, however), and turn now to consider its true relation to nature.

[6] See Ward, Lester F., "Dynamic Sociology," Vol. II, pp. 103–106. Ward says, "Natural phenomena include all genetic phenomena, and direct teleological phenomena in addition; artificial phenomena coincide and are strictly identical with indirect teleological phenomena," but he does not point out that unintended results of telic action belong with natural phenomena and are subject to the same laws.

[7] Complete Works, Concord Ed., Vol. I, pp. 5, 24.

The prevalent conception as to the relation of nature and art is, perhaps, that they are antagonistic. Primitive men, observing that some natural phenomena were harmful, some helpful, peopled the world with bad spirits and good spirits, which they sought to propitiate. Thus, early arose exorcism, incantation, prayer, sacrifice and the various other forms of religious ceremony addressed to such antagonistic spirits. Later, either by an inference from the political organization existing at the time, or from the mental tendency of man to integrate his conceptions, possibly from both, there arose the idea of two great and ruling antagonistic powers or principles operating in the world. Almost all the great religions give evidence of this view. In the Ancient Persian religion, for instance, we find Ahriman the God of Evil, and Ormuzd the God of Good; in the Hindu religion, Vishnu and Siva; in the Egyptian, Osiris and Typhon; and among the Christian nations, God and Satan, and the conception of good and evil principles. Evil is usually attributed to nature, including man's nature. Man, it is said, is prone to evil, "born unto trouble, as the sparks fly upward." By nature he is wayward and sinful. The spiritual man is at war with the carnal, *i.e.*, the natural, man. Conscious moral effort, then, that is art in the field of ethical action, should be constantly directed towards checking man's evil tendencies, that is, to antagonizing nature as manifested in him. Repression thus becomes the object of the moral life. Man arises, civilization advances, in proportion to man's success in opposing nature. This is the prevalent religious view.

Science has done something, too, to encourage this theory of antagonism between nature and art. It has revealed and emphasized the fact that there are, indeed, opposing forces and principles in nature—gravitant and radiant forces, attraction and repulsion, heredity and variation, growth and decay, imitation and invention, etc., and it admits, of course, the existence of good and evil. It has made much, too, of the fact of universal struggle, without which nothing could exist either in nature or in art. For these and like reasons the idea has developed that nature and art are antagonistic.

Curiously enough, this theory of antagonism received its strongest support from one of the greatest of scientific men. I refer, of course, to Professor Huxley who, in his celebrated Romanes lecture entitled "Evolution and Ethics," delivered in Oxford on May 18, 1893, took the ground that the ethical process (art) is directly opposed to the cosmic process (nature). He says:

> Social progress means a checking of the cosmic process at every step and the substitution for it of another, which may be called the ethical process. . . . The practice of that which is ethically best—what we call goodness or virtue—

involves a course of conduct which, in all respects, is opposed to that which leads to success in the cosmic struggle for existence. . . . Let us understand, once for all, that the ethical process of society depends, not on imitating the cosmic process, still less in running away from it, but in combating it.

Antagonism, he declares, is everywhere manifest between the artificial and the natural.[8]

All this, of course, amounts practically to the theological view just mentioned, and confirms the prevailing idea of the antagonistic relation of nature and art.

That this theory, however, is incorrect, or at all events misleading, may be shown by considering once more the simple illustration used at the beginning of this discussion with the object of seeing just what takes place in the matter of transforming a natural into an artificial phenomenon. When the water in a river is turned into a prepared channel in order to irrigate a field, the force of gravitation is not combatted, it is merely directed. Such action does not even suggest a combat. Nor do we talk of combating a horse, for instance, when we are merely driving it; and yet the process is practically the same as in the former case. The situation is not different with respect to moral actions, that is to say, in ethics. The cosmic process is not opposed to the ethical process, it is altogether passive and indifferent to it. And so nature and art may not properly be represented as antagonistic. They may appear to be so at first, but close examination shows that this is a delusion. Goethe expresses the correct idea in his poem on "Natur und Kunst." He says:

> Natur und Kunst die scheinen sich zu fliehen,
> Und haben sich, eh' man es denkt, gefunden.
> Der Widerwille ist auch mir entschwunden,
> Und beide scheinen gleich mich anzuziehen.

Now, since art, as we have said, is practically limited to the conscious acts of man, we have, in the discussion of the relation of nature and art, necessarily considered the relation of nature and man. If art and nature are in conflict, then it must be that man and nature are in conflict, and this is almost the general view. We speak of "conquering" nature. Life, by ancient philosophers and by the practical men of affairs to-day, is represented as a fight. "To live is to fight," said Seneca. Beaumarchais chose for his motto, "My life is a fight." Goethe said:

> Den ich bin ein Mensch gewesen,
> Und das heist ein Kämpfer sein.[9]

[8] Huxley, T. H., "Evolution and Ethics," New York, 1911, pp. 13, 81, 82, 83.

[9] This and the immediately foregoing quotations are used by F. G. Nicolai in the "Biology of War," p. 36.

In an address of the late Secretary of the Interior, Franklin K. Lane, he said, "The one fight, the enduring contest, is between man and physical nature." And again, he said, "this world was made for a fighting man and none other." These are but samples of current expressions on this subject. Even followers of the "Prince of Peace" still speak of "fighting the good fight of faith," apply military terms to their leaders, call themselves "soldiers," plan "campaigns," and stimulate themselves by singing hymns of "battle" and shouting peans of "victory." The highest encomium of a man in public life pronounces him a "fighter," and the warrior is still, as heretofore, the beau-ideal of mankind.

All this betrays a singular misapprehension. God and nature are not at strife. No more is art and nature, or man and nature. The function of man with respect to nature is employment or control. And if skilful and ideally effective control of nature's forces, as manifested in the physical, vital, psychic and social world, be taken as the standard, the fighter is a fool, for fighting is the least intelligent of all methods employed in the control of nature.

If it be claimed that the representation of life as a fight is a mere metaphor, then it should still be said that the metaphor is misleading and pernicious, for it tends to excuse and justify the war of man against man, and to evoke the raptures which some profess to feel "over civilized human beings crawling about on the ground and shooting at one another."

But let us glance more closely at the relation of art and nature, limiting our view to simple illustrations. Consider, for instance, the art of invention. Does the relation of the inventor to the force or phenomena he wishes to control suggest antagonism? Does his procedure imply a fight? The very idea is absurd. What he undertakes to do is to fit means to an end, the end being the turning of a natural force, or forces, into channels of human advantage. He studies the forces involved and the materials for controlling them, and selects the appropriate means. It is the same in all the other arts—in agriculture, in legislation and in education—for all the arts are of essentially the same nature.

It is the same, too, in the moral life. Evil is only the result of misdirected impulse, passion and propensity. Man's natural proclivities are really manifestations of vital and mental forces. They are not to be conquered or put down, any more than physical forces are to be conquered or put down. They are only to be controlled or directed to the achievement of worthy ends. Good and evil are alike the result of the operation of natural forces, as much natural as the physical forces. These forces may be controlled and directed. Good and evil are relative terms. One may be turned into the other

by changed circumstances, or by directing the force that gives rise to it into a different channel. Self-control is, therefore, the essence of the moral life.

Concluding this part of the discussion, we may say that man is a product of nature. He is a natural outcome of the cosmic process, that is, of evolution. By virtue of his possession of intelligence he has become a student of nature, and by the application of his intelligence he has in some measure learned to control it. He is, to the extent of his knowledge, its master. But his mastery is not the result of a fight against it. Bacon says that we conquer, that is, master, nature not by opposing but by obeying her, that is, by acting in harmony with her laws. It is foolish to think of fighting nature. She is not to be fought and conquered but to be studied and used. Nature is not opposed either to art or to man.

> Every shape and mode of matter lends
> Its force to the omnipotence of mind.

There is another theory of the relation of nature and art that deserves at least a passing notice. It is the theory that the whole creation centers in man, the darling of the universe; that not only were all things in nature created for him, but also that there is in nature a beneficent agency operating in the direction of his welfare and advantage; it is the anthropocentric theory.

Although this view is still adhered to by the orthodox in theology, and has been defended in one of its forms by no less a scientific authority than Alfred Russel Wallace, the evolutionary explanation of the various and marvelous adaptations that formerly were regarded as evidence of design in nature, and the numerous dysteleological facts of nature pointed out by Haeckel, Metchnikoff and many others have widely discredited it.

The existence of an active beneficent tendency in nature is negatived by the facts of everyday observation, as well as by the basic principle of all science, namely, the universality and changelessness of law. In a flood, fire, hurricane or earthquake, the natural forces involved are observed to operate on the line of least resistance, no matter what devastation of life and property may result. An authenticated exception to this mode of action would not only destroy the exactitude of science, but would also introduce uncertainty into all the practical affairs of men.

It is strange how long it has taken the world to see that a world of special providence is practically equivalent to a world of chance; that the certitude of science is better than miracles; and that "the best of all possible worlds," considered merely as a theater for artificial action, that is, for the intelligent activities of man, is a world

of fixed and unchanging laws. The only sense in which nature is anthropocentric is that of its potential utilization. It is beneficent only in the sense in which the unused minerals of the earth, uncut timber, unharnessed water power, uncultivated soil, unconfined steam and uncontrolled electricity are beneficent. It is not nature but art that is anthropocentric.

> Strong, simple, silent are the steadfast laws,
> That sway the universe, of none withstood,
> Unconscious of man's outcries or applause,
> Or what man deems his evil or his good.

Nature, then, through all its departments is entirely passive with respect to art. It is amoral. It knows nothing, it cares nothing, for man, that is, for art. Good and bad alike, pleasure and pain, joy and sorrow, are merely the results of the particular relations that man sustains to it. Some look at it and, seeing that it is "red in tooth and claw," cry out against its cruelty. Others, beholding certain beautiful natural adaptations to the needs of man, fall into raptures over the beneficence of nature. But nature is neither cruel nor kind, neither malevolent nor benevolent. It is merely a reservoir of materials and forces which are at the service of man. "Nature," truly said Emerson, "is thoroughly mediate. It is made to serve. It receives the dominion of man as meekly as the ass on which the Savior rode. It offers all its kingdoms to man as the raw material which he may mould into what is useful."[10]

What, then, is the true relation of nature to art? It is the relation of iron to the moulder and manufacturer; of bricks, stone and mortar to the builder; of clay to the potter; of marble to the sculptor; of seed and soil to the farmer; it is the relation of steam to the mechanical and electricity to the electrical engineer; it is the relation of means of effort to the only being in the world capable of conscious achievement. In short, the relation of nature to art is the relation of means to purpose. Nature is the opportunity of art.

Now, glance for a moment at the amplitude and variety of the means provided by nature for the uses of art. We live on a globe, which, though small as compared with some of the other planets, is yet large enough for any purpose thus far conceived by man. It is stocked with a wonderful supply of materials and forces; with metals and other minerals to the number of perhaps a thousand; with millions of forms of plant life; with hundreds of thousands of species of animals. All this vast array of materials in the animal, vegetable and mineral world constitute only man's "visible means of support." In addition there are also the invisible forces of the

[10] *Op. cit.*, p. 40.

physical, vital, psychic and social worlds, which make nature dynamic and creative, which are all subject to the control of intelligence and which, when intelligently directed, may multiply man's power to an inconceivable degree. Truly man's patrimony is marvelous; he lives in a wonderful world.

> The hills,
> Rock-ribbed and ancient as the sun. The vales
> Stretching in pensive quietness between;
> The venerable woods, rivers that move
> In majesty, and the complaining brooks,
> That make the meadows green, and poured round all,
> Old ocean's gray and melancholy waste,—
> Are but the solemn decorations all
> Of the great (Home) of man.

Now, observe the comparatively slight degree in which man has thus far employed the materials and forces that are ready to his hands. Gold, silver, copper, iron, tin, lead and mercury have been known and used since the beginning of history. Glass, a fused combination of the silicates of sodium and calcium, or of potassium and calcium, was employed for useful or ornamental purposes by the ancients. Many other elements and compounds have been brought into common use. But, of the 80 or more chemical elements, half were undiscovered at the beginning of the last century. How many more are yet to be discovered we do not know. Radium, only recently found, is certainly the most curious and may yet prove to be the most useful of all. Elements supposed to be of no use, like lanthanium and neodynium, have been found to be in some of their compounds of inestimable service. Creative chemistry, inorganic and organic, is in its infancy. We have about a thousand mineral species. The inorganic compounds artificially formed from them number about 10,000, but the possible combinations are infinite. Organic compounds are said to number about 100,000, but here, too, the possibilities are infinite. We have already attained the artificial production of many of our foodstuffs, including an artificial substitute for sugar, only albumen remaining to be synthesized. The forces of gravity, steam, heat, light and electricity are used, but only to a very limited extent. The water power of the world, to say nothing of electricity and the other great physical forces, many no doubt undiscovered, is sufficient to do all its work, and more. The direct exploitation of solar energy, certainly possible, would render the earth habitable to many billions more people than it now contains.

From the vegetable world we derive food, clothing, shelter, ornaments, etc., drugs, balsams, resins, gums, dyes, oils, perfumes, spices,

etc., etc., but most plants are yet unemployed, those used are too often destroyed and only recently have we begun to create new forms of plant life, the possibilities in this direction being also infinite.

Of animals we have domesticated a few, utilized the skins and flesh of many, and utterly destroyed some which, if preserved, might have added immeasurably to the support, convenience and esthetic enjoyment of life. The passenger pigeon, for instance, innumerable within the memory of men now living, is as extinct as the dodo. The buffalo is a curiosity. Our game birds and beasts are rapidly disappearing. The "pot-hunter," so far from being conscious of his true significance in a world economy, or from being ashamed of the part he is playing in it, enjoys having his picture taken surrounded by the evidences of his "prowess!"

Two things, then, are clear: First, man has scarcely made a beginning in the employment of the materials and the forces of nature, nature being for the most part wild, untamed, unused; secondly, his use of these materials and forces is largely abuse.

To be sure, man prides himself on what he has achieved in the sciences and the arts. It is much in comparison with nothing, but almost nothing in comparison with what may be done. The physical sciences have rapidly advanced during the past three centuries because the world has been blessed with a few men who loved truth for its own sake and pursued it in spite of all opposition; but particularly because the physical arts derived from them have lent themselves to the immediate and practical purposes of men who knew how to use them in the pursuit of their own ends. The biological sciences have made great strides since Darwin, and a beginning has been made in the arts of cultivation and of breeding. Psychology until recently was a pseudo-science, and the corresponding arts of education and individual and institutional management are still largely empirical. But the great science of society is yet struggling for recognition, and the art of social control, of social self-direction, of orderly progress, is but faintly manifested in a few sporadic attempts at social legislation. We are indeed "in the stone age of politics." Society as a whole has not begun to look after its own interests. It is not Man that is intelligent, but men. Mankind as a whole has yet to develop a unity of purpose and an organization of effort which alone can enable it to utilize the materials and forces of nature in the promotion of its own progress, and thus build the society of which some have dared to dream. As to the abuses of nature, Alfred Russel Wallace has so well expressed the facts and their significance that I will quote his words. After dwelling upon the marvelous variety of the useful and beautiful

products of nature, and how this variety and beauty, even their strangeness and ugliness, excite in us admiration, wonder and curiosity, the emotions at the basis of observation and experiment and therefore of all science and philosophy, he says:

> These considerations should lead us to look upon all the works of nature, animate or inanimate, as invested with a certain sanctity, to be *used* by us but not *abused*, and never to be recklessly destroyed or effaced. To pollute a spring or a river, to exterminate a bird or beast, should be treated as moral offences and as social crimes. Yet during the past century, which has seen those great advances in the *knowledge* of Nature of which we are so proud, there has been no corresponding development of a love or reverence for her works; so that never before has there been such widespread ravage of the earth's surface by destruction of native vegetation and with it of much animal life, and such wholesale defacement of the earth by mineral workings and by pouring into our streams and rivers the refuse of manufactories and of cities; and this has been done by all the greatest nations claiming the first place of civilization and religion. And what is worse, the greatest part of this waste and devastation has been and is being carried on, not for any good or worthy purpose, but in the interest of personal greed and avarice; so that in every case, while wealth has increased in the hands of a few, millions are still living without the bare necessaries for a healthy or a decent life, thousands dying yearly of actual starvation, and other thousands being slowly or suddenly destroyed by hideous diseases or accidents directly caused in this cruel race for wealth, and in almost every case easily preventable. Yet they are not prevented, solely because to do so would somewhat diminish the profits of the capitalists and legislators who are directly responsible for this almost world-wide defacement and destruction and virtual massacre of the ignorant and defenceless workers.[11]

Here, then, in brief, is the situation presented by an impartial study of nature and art: a race of intelligent beings dwelling in the midst of a wonderful supply of materials and forces, all susceptible of use through knowledge; materials and forces so abundant and varied that by means of them the lot of man may not only be somewhat "ameliorated," but improved beyond the dreams of poet or seer.

> The men of earth have here the stuff
> Of paradise, we have enough.
> We need no other stones to build
> The temple of the unfulfilled—
> No other ivory for the doors—
> No other marble for the floors—
> No other cedar for the beam
> And dome of man's eternal dream.

And yet, here are these intelligent beings abusing nature, and destroying through ignorance and greed many irreplaceable means

[11] "The World of Life," Moffatt, Yard & Co., New York, 1916, pp. 300-301.

of human welfare; working at cross-purposes, quarreling and fighting, using the societal organizations, that have come into existence largely through accident, to defeat and destroy each other; glorying in "the pomp and circumstance of war," not sufficiently developed to be ashamed of it; failing to unite in the achievement of a world purpose when presented with a unique opportunity to do so; shouting "patriotism" and failing to perceive that the highest virtue of patriotism is in its mediation to cosmopolitanism, and that man's true Fatherland is not a country but the globe, and now and then gravely marching to temples of worship to beseech the Lord to do for them what they might easily do for themselves. No wonder the Flood!

The situation, however, is not without elements of hope. Men, seeking their own advantage, have demonstrated the enormous possibilities of utilizing the materials and forces of nature as means of promoting the welfare of the individual. None denies that nature may so be increasingly utilized. There is no end to such utilization short of the complete artificialization of nature. "Art," said Emerson, "must be carried out and upward into the kingdom of nature and destroy its separate and contrasted existence. Nothing less than the creation of man and nature is the end of art."

Now, it is an easy inference that what an individual can do and is doing for himself a collection of individuals, that is, society, may do and ought to do for itself. Society is a domain of natural forces. Its progress thus far has been largely a natural process—a result of natural selection, an incidental and unintended outcome of activities of men which though telic were only so from the standpoint of the individual. Society is a unity, a "collective being." How, then, can it be denied that society may and ought to utilize nature after the manner in which the individual has set the example? The process in each case is essentially the same.

To exercise control over nature but two things are necessary, the will and the knowledge. The knowledge that it can be done evokes the will, so that we have only to provide ourselves with the former and the latter will take care of itself. "As we understand nature better," says Ritchie, "and as we understand human nature better, we can secure adaptation and adjustment by bending nature in many ways to ourselves instead of bending ourselves in every respect to nature."[12]

Knowledge is power. Knowledge of the materials and forces of nature, of all nature—physical, vital, psychic and social—is the power to control nature. Knowledge, therefore, is the sole desideratum.

Of course, such knowledge implies imagination and idealistic

[12] Ritchie, D. G., "Natural Rights," p. 112.

construction of the ends we wish to serve. The moment we undertake to use our knowledge, to exercise any control over nature, we must have some purpose, some end in view, and if the end is a conception of improved individual or social life, it is an ideal. As already seen, there can be no art without a purpose, but a purpose is essentially an ideal. We can not understand, then, the idea that the formation of ideals is an illegitimate procedure in science. Professor W. G. Sumner says:

> Men who rank as strong thinkers put forward ideals as useful things in thought and effort. Every ideal is a phantasm; it is formed by giving up one's hold on reality and taking a flight in the realm of fiction. When an ideal has been formed in the imagination the attempt is made to spring and realize it. The whole process seems to be open to question; it is unreal and unscientific; it is the same process as that by which Utopias are formed in regard to social states, and contains the same fallacies; it is not a legitimate mental exercise. There is never any correct process by which we can realize an ideal. . . . What we need to practice, on the contrary, is to know with the greatest exactitude, what is, and then plan to deal with the case as it is by the most approved means.[13]

Exactly so, but how, or why "deal with the case as it is," unless to some end? Professor Sumner's proposal is inconsistent with his doctrine. Why should every ideal be a phantasm? Why may it not be a scientific construction on the basis of facts? All that we contend for is that society should find out "with the greatest exactitude" its present conditions and possibilities and then "plan to deal with the case as it is by the most approved means," and that necessitates a social ideal. Mere idealistic speculation is, we admit, an idle pastime. But ideals, social as well as individual, may be constructed on the basis of scientific facts and tendencies, and so determined they are the practical ends of the control by art over nature.

If there are no limits to knowledge, and this is usually regarded as the true view, then there is no limit to the power of knowledge or of art, that is, to what man equipped with knowledge can do. As the field of knowledge is the whole universe of phenomena, cosmic, organic, psychic and social, so the possibilities of control are unlimited in scope. Already the material forces have in large part been brought under the dominion of man; in a lesser but still in large part the vital forces have been brought under his direction; in a yet lesser degree, because man possesses less knowledge in this field, the social forces have also been turned towards the production of improved social conditions. Little has yet been done, because little is yet known in this field. But, given the necessary knowledge

[13] Sumner, W. G., "Earth, Hunger and other Essays," New Haven, 1913, pp. 25–26.

of social relations, who will dare to set a limit to the achievements of art, that is to say, of man, in the matter of realizing here on earth the "kingdom of heaven"? Of old it was said of man that his Creator gave him universal dominion. "Thou madest him to have dominion over the works of thy hands; thou hast put all things under his feet." Science confirms this declaration, only this dominion must be won by the pursuit of knowledge and the exercise of art. And so we may say, as Professor Huxley said, we "see no limit to the extent to which intelligence and will, guided by sound principles and investigations, and organized in common effort, may modify the conditions of existence for a period longer than that now covered by history."[14] He meant, of course, that period when in the course of cosmic evolution the world is to become a dead world because of the dying heat of the sun. But that period is so remote as to give us no concern.

The human race is supposed to have existed between 200,000 and 300,000 years, let us say one quarter of one million years. It has been conscious of its existence only about 10,000 years, and really alive as a psychic being less than 5,000 years. The most it has accomplished of any value to itself has been done within 2,000 years, and its great work within 200 years. In a word, relatively speaking, man has only just begun to exist. His golden age, as Saint Simon said, is before him and not behind him. His history is but the threshold of the Psychozoic age. The whole of that immense period lies before him. The conditions of existence on this earth are now at their optimum, abundance of air and water, heat and light, great variety of surface, soil, climate, mineral resources and all the materials and forces of nature ready to yield to the magic wand of science. There are no indications that these conditions will change in an entire geological epoch. These favorable conditions are certainly liable to last as long as the Tertiary period just closed has lasted, viz., 3,000,000 years. They may continue during the first half of the Psychozoic period of Mars, or 12,000,000 years. And what does a million years mean? Contrast (the human) period with any full geologic epoch and reflect upon its significance. For us the Psychozoic age, or any considerable part of it, means *eternity*.[15]

Now, given the three factors—practically an eternity of time, an almost infinite amount of utilizable materials and forces and a race endowed with intelligence capable of practically infinite development—and the possible progressive realization of a condition of society corresponding to, or surpassing, the loftiest dreams of the poets, is indisputable. James Russell Lowell, to mention but one of the dreamers, declared, in his "Ode to France," that

[14] *Op. cit.*, p. 85.

[15] Ward, Lester F., "Glimpses of the Cosmos," Vol. VI, New York, 1918, p. 258.

> Down the happy future runs a flood
> Of prophesying light;
> It shows an earth no longer stained with blood,
> Blossom and fruit where now we see the bud
> Of Brotherhood and Right.

And in another poem, "Elegy on the Death of Dr. Channing," he said that

> From off the starry mountain peak of song,
> Thy spirit shows me, in the coming time,
> An earth unwithered by the foot of wrong,
> A race revering its own soul sublime.

But what we have tried to indicate, and in a way to prove, is that from the none too lofty peak of present knowledge, fact and achievement, and through the dry light of science, the same ideal is visible, not as a poetic fancy, not as a delusive mirage that vanishes as we look, but as a possible future condition of society if men will but unite and apply art to the general improvement of mankind. Obviously, there will be no general unity of purpose until through a new education the social possibilities of unified and intelligent effort begin generally to appear. But in him who glimpses these possibilities and perceives that they are based upon scientific facts and laws, there is awakened an enthusiasm for ordered social progress and a sense of duty that are essentially religious. The religion of orthodoxy is fast losing its hold. Many of the religious beliefs drawn from the limited knowledge and active imagination of primitive man are destined to disappear. But here, in a purely scientific view of nature and of art, and of the relation of intelligent man to the world of nature, and the social possibilities that grow out of such relation, are the elements which might be made the basis of "a new religion," the religion of science, the religion of humanity, a religion which of itself should be satisfying to the truly emancipated soul.

MATHEMATICS AS A CAREER

By Professor C. J. KEYSER
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THE aim of this article is to help college and university students having a bent for mathematics to answer some of the questions they ought to consider before deciding whether or not to devote their lives to this field of science.

The questions to be considered may be taken up under the following four heads: "Interest and Ability," "The Nature, Scope, Vitality (or Progressiveness) and Dignity of Mathematics," "The Period of Preparation," "The Mathematician's Rewards."

INTEREST AND ABILITY

In speaking of mathematical ability I shall mean *native* mathematical ability, in accord with the proper sense of the familiar saying that the mathematician is *born*, not made. Every one knows that mathematical ability and interest in mathematical study often go together. And it is commonly believed that the two things are always associated in such a way that intensity of interest implies a high degree of ability, and that superior ability implies corresponding interest (actual or potential). But that belief is erroneous. Every experienced teacher of mathematics knows very well that a student whose mathematical ability is meagre may yet feel and manifest a lively interest in mathematical studies. On the other hand, it occasionally happens that a student having indubitably great mathematical gifts has relatively slight interest in the subject. What I have said of mathematics is equally true of every other form or field of activity.

It is thus evident that what may for a time seem to a student to be an inner summons to mathematics or another subject may or may not be a genuine call thereto. Such a summons requires to be scrutinized carefully, for the choice of a vocation is a momentous act. I do not mean that choice should be deferred in the hope of resolving all doubt, for in such matters complete elimination of uncertainties is impossible. Yet one must decide or drift. But, although the decision must be adventurous, the adventure need not be rash: it may await, not certainty, but the weighing of probabilities.

I believe it safe to say that, with very rare exceptions, a student may not wisely choose mathematics for a vocation unless he has

asked, with respect to himself, and has been able to answer affirmatively, the following questions: Is my seeming interest in mathematics genuine? Is it an abiding interest? Does it exceed my interest in every other subject? Is it deep and strong enough to stimulate my powers to their highest possible activity and cause mathematical work to be for me, not irksome toil, but a labor of love? Have I sufficient mathematical ability to read a solid mathematical work with fair facility and good understanding? Does my mathematical ability exceed my natural ability in every other subject? Do I possess in fair measure the natural gifts essential to the qualifications of a successful teacher of high-school pupils or college students or university undergraduates?

Of the foregoing questions the first one is intended to guard the student against the danger of mistaking for interest in mathematics such transitory delights as a bright student is likely to have in class-room competitions under the quickening influence of a live teacher. If a student have genuine interest in the subject, he will know it; but if his "interest" be spurious, he may be deceived.

The last one of the questions appears to be justified in view of the fact that in our country young men aspiring to a career in mathematics have seldom been able to escape the necessity, even when they have desired to do so, of giving a good deal of their time and energy to the work of undergraduate instruction, and that relief from such necessity does not seem probable.

Ordinarily, a student may not hope to arrive at trustworthy affirmative answers before his studies have advanced far enough at least to include substantial courses in analytical geometry and the calculus. In any case he should seek the counsel of his instructors, especially if they be candid men of mathematical reputation and good judgment.

A more difficult problem presents itself in the case of those rare students who have no decisive predilection for a single subject but have talents and interests qualifying them well and equally for adventure in any one of two or more great fields. It is a pity that such a student can not wisely make it his vocation to cultivate all the fields at once or in succession. There is always something tragic in having to specialize, for in a profound sense the subject of all science is one whole. But the whole is too vast and complicated for the limited powers of one man; whence the necessity for division and for concentration upon a fragment—a necessity whose tragic quality is felt with special keenness by a student of diversified gifts and interests. The fields in question may be or seem to be widely sundered, as geology and linguistics, for example; or they may be obviously adjacent, closely related, interpenetrating, as physics and

chemistry, for example, or zoology and botany, or philosophy and mathematics. If the fields be intimately related a student of the mentioned type may aim at a career in two or more of them combined *provided* he be endowed with a measure of genius like that of Helmholtz, for example, or Henri Poincaré, who won eminent distinction in astronomy, in physics and in mathematics. But men of such capabilities are exceedingly rare. Ordinarily, a student whose tastes and talents qualify him well and equally for two or more important subjects ought to choose one of them definitely and resolutely as a *vocation,* reserving the others not less definitely and resolutely as *avocations;* for ordinarily such a decision will be most favorable to health and happiness, to depth and breadth of culture, to good citizenship in the commonwealth of science, and to the service of mankind.

Mathematical Research Ability and its Test

I have thus far said nothing about research, having reserved it for special consideration because of its grave importance. There is hardly another term so often heard in university circles and no other is mentioned with quite so much respect. Indeed, one sometimes gains the impression that scientific men, or some of them, regard research as being, in comparison with all other activity, not only awe-inspiring but sacred or holy, almost divine. Not infrequently men speak of it with a solemnity like that of a sinner recommending virtue and righteousness, and doubtless they sometimes do it from similar motives, conscious or unconscious.

What does the term mean? In current use it has two meanings, differing in respect to dignity, a minor meaning and a major one. In mathematics the minor meaning of the term research covers a large variety of work which, though valuable, involving something of the spirit and art of discovery and adding somewhat to the body of mathematical knowledge, yet requires neither creative genius nor a *very* high order of talent. I refer to such work as that of effecting improvements in the exposition of classical doctrines; the discovery of new theorems of ordinary difficulty, interest and importance; new demonstrations of important old theorems; the invention of new but subordinate methods; the detection and correction of imperfections in established theories; and so on. Much of the matter found in journals devoted to what is called research is of the sort I have indicated. Of course, it does not represent research in its major sense.

The major meaning of the term, mathematical research, is clearly revealed and rightly represented by nothing save the great achievements of creative mathematicians. Such creative activity

assumes various forms. It may show itself in the discovery of a powerful *method*, like the analytical geometry of Descartes and Fermat or the calculus of Newton and Leibnitz; it may show itself in the creation of a great *doctrine*, like the projective geometry of Desargues and Poncelet or the function-theory of the complex variable (Cauchy, Riemann, Weierstrass); it may show itself in the form of historical research, as in the monumental *Geschichte der Mathematik* of Moritz Cantor; it may show itself in the form of contributions to the logical foundations of the science, as in the *Principia* of Whitehead and Russell or the *Tractatus* of Wittgenstein; it may show itself in the *applications* of mathematics to empirical science, as in the Einstein Theory of Relativity or the Quantum Theory of Planck.

Is it possible for a student to ascertain with a good degree of certainty whether, in the event of his choosing mathematics for a vocation, he may confidently aspire to a research career in the subject? Yes and no. If he can answer affirmatively the foregoing test questions respecting interest and ability, then he may, I believe, fairly assume that his powers are adequate for research in the minor meaning of the term; but with respect to the major meaning no such guaranty is possible. Just here the element of adventure, which choice always involves, is seen at its maximum. For there can be no conclusive evidence of having the power to do great things except achievement.

The Nature, Scope, Vitality and Dignity of Mathematics

The nature of mathematics: A competent student of mathematics whose studies have not advanced beyond a solid year of calculus will not know profoundly or critically what mathematics essentially and distinctively is but he will have felt its appeal and gained some sense of its power. In this brief essay not much can be said regarding the essential nature of mathematics. I venture to refer such students as may be interested in that great question to my "Mathematical Philosophy,"[1] where a serious attempt has been made to set the matter in clear light and where they may find a clue to the literature. Here I can barely touch the subject and must content myself with making a few careful, though unargued, statements having for their principal aim to discriminate justly and clearly between mathematics and natural science.

Natural science employs logic as an instrument, a tool. But to speak of logic as a tool of mathematics is meaningless. Logic is not a tool of mathematics—logic *is* mathematics. All strictly mathematical propositions are propositions of logic, and conversely. But

[1] E. P. Dutton and Company, New York.

no propositions of natural science are propositions of logic, or mathematics, though the latter propositions are such that the best of the former can not be established without them.

Mathematical propositions are true *unconditionally*—which means that their validity is independent of the facts investigated by natural science. But propositions of natural science are only true *conditionally*—on condition, that is, of their agreement with the possible facts asserted by them. Suppose, for example, that p and q are propositions of natural science. The mathematical proposition—if p is true and p implies q, q is true—is true no matter whether p or q or p' implies q' is true or false.

All propositions of natural science are *empirical,* which means that, if a proposition of natural science be true, knowledge that it is true can not be gained by inspecting the meanings of the proposition's terms but rests ultimately upon sense-perception—upon external observation—upon comparison of the proposition with the fact asserted by it. *No* mathematical proposition is *empirical;* knowledge that a mathematical proposition is true can not be gained by sense-perception—by comparison of the proposition with any fact or facts of the external world; the evidence of its truth is wholly contained in the meanings of its terms; and knowledge of its truth results from analyzing those meanings. The processes of what is called mathematical proof are nothing but the processes of such analysis.

Mathematics is silent respecting the empirical realities of life and the world, Yet it is infinitely important as a means for our dealing with them effectively. For it is mathematical propositions, and only they, which enable us to advance by *inference* from given propositions which do relate to empirical realities to new propositions relating to them. Without the process of such *inference,* made possible by mathematics, natural science, even civilization itself, would be impossible.

The scope, vitality and dignity of mathematics: No student need hesitate to choose mathematics for his vocation because of any fear that this subject, when compared with others, may be found to be inferior to some of them in scope, or in vitality and progressiveness, or in dignity.

Consider the question of scope. We know that the world of empirical reality—the subject of Natural Science—is so vast and complicated that each of the natural sciences has for its scope but one aspect or fragment of the world. But we do not know whether the facts composing the world of empirical reality do or do not constitute an infinite multitude; and so we can not assert that the answers, if we had them, to all the questions that all the natural

sciences combined might ask would constitute an infinitude of propositions. With respect, however, to non-empirical truth, with respect to facts of logic, with respect, that is, to propositions that are unconditionally true, the situation is different: we know, from the internal evidence of the case, that mathematical propositions, known and unknown, together constitute, not merely a vast multitude, but an infinite one. Even the body of *known* mathematical propositions is so large that, as I have elsewhere[2] said, "no man, though he have the wide-reaching arms of a Henri Poincaré, can contrive to embrace them all."

With respect to vitality and progressiveness it may be confidently said that mathematics is not surpassed by any branch of science. Its developments in our day proceed so rapidly and in so many directions that the ablest men, being unable to follow all the developments, are obliged to specialize within the general field. Ours is indeed the golden age of mathematics. Not less than eight international congresses of mathematicians were held prior to the World War. More than 500 scientific journals are devoted in part, and more than two score others are devoted exclusively, to mathematical publication. As many as 2,000 mathematical books and memoirs drop from the press in a single year. In all of the great culture nations are found flourishing mathematical societies. The American Mathematical Society, which is primarily devoted to research, and publishes two journals, has about one thousand members. The membership of the Mathematical Association of America, which publishes one journal, is still larger. And in our country, as in others, there are numerous organizations aiming at improvement in the teaching of elementary mathematics.

Nor is the activity thus indicated confined to "pure mathematics." "Applied mathematics" is not less alive. And here I must say a word about those two terms. It is customary to speak of mathematics, of pure mathematics, and of applied mathematics, as if the first were a *genus* owning the other two as *species*. The custom is unfortunate because it is misleading. "Pure mathematics" is a superfluous term, for it simply means mathematics and nothing else. The term "applied mathematics," which came into use before the essential nature of mathematics had been discovered, is a misnomer. The uses or applications of mathematics no more constitute a species of mathematics than the uses or applications of a spade constitute a species of spade.

Of present-day activity in applications of mathematics to questions of empirical science the tokens are numerous and striking. It will be sufficient to refer to two of them, mentioned before—I mean

[2] "Mathematical Philosophy," p. 21.

the Relativity theories, of which every one has heard, and the not less significant Quantum theories of Planck and others. These two examples have special value on another account. For they teach a most important lesson which it is very hard for the world to learn and they show at the same time how silly it is to debate whether devotion to mathematics or devotion to its applications is the better form of scientific service. The lesson is that a mathematical theory, however abstract and seemingly "useless," will sooner or later get applied to problems of empirical science. For example, the mathematical theory of probability, which had its origin in common games of chance, to-day plays a fundamental rôle in Quantum theory and the kinetic theory of gases. Again, nothing could appeal less to a born utilitarian than the frightfully abstract and complicate Theory of Tensors constructed long ago by Riemann and Christoffel. Yesterday, however, that idle theory became the "backbone" of the General Theory of Relativity. A similar tale could be told of many other mathematical theories long pooh-poohed as idle curiosities, non-Euclidean geometrics, for example, and the doctrines of hyperspaces. It is not only astronomy and physics and chemistry that are open to the invasion of mathematical students with a bent for applications but philosophy and psychology, botany and zoology, statistics and economics, and every variety of engineering.

In view of the foregoing considerations it would be superfluous to inquire concerning the relative dignity of mathematics in the general assembly of sciences and arts. Students desiring to inform themselves in respect to the esteem in which mathematics has been held from time immemorial by eminent men and women representing all fields of intellectual and spiritual activity may be referred to Professor Moritz's superb "Memorabilia Mathematica."

The Period of Preparation

What is to be said under this caption with reference to mathematics applies quite as well to every other cardinal subject. The period of preparation usually includes two or three years of university residence devoted to what is called graduate study subsequent to graduation from college. During these years the student will be in fact, if not officially, a candidate for the degree of doctor of philosophy, and his period of preparation for a scientific career will usually terminate when he has gained the degree. To gain the degree he must produce a dissertation embodying the result of fairly independent and somewhat original work and must pass an examination, which may be oral or written or both, in the general field (or fields) of his studies.

The gaining of the doctorate is not regarded as conclusive evi-

dence that the student has research ability in the major meaning of the term as above explained. It is regarded, and rightly regarded, as signifying that the student has attained a fairly high degree of scholarly competence in his field of study and that he possesses research ability in at least the minor meaning of the term. On this account the fact of having won the doctorate is distinctly helpful, and in some instances is even essential, in obtaining a position, especially a college or university appointment, and thereafter in obtaining promotion. It is true that not all doctors of philosophy are scientifically productive; on the other hand, some of the most productive scholars within and without the universities have not held the doctorate; it is also true that pursuit of scholarship and pursuit of a degree, though they are compatible, are not the same. Nevertheless, in view of the prevailing practice, a student aspiring to a university career in mathematics or another subject will find it advantageous to make whatever sacrifice may be necessary for gaining the doctorate.

The Mathematician's Rewards

First, a word respecting material rewards. Having gained the doctorate, the young mathematician can readily obtain a college or university instructorship at an initial salary of perhaps $2,000. He will instruct undergraduates and may be permitted to offer a graduate course. If he be a successful teacher and especially if, in addition to that, he wins fair repute for research work, he may confidently expect advancement, in three to five years, to an assistant professorship with a salary of $3,000 to $4,000; and, in ten to fifteen years, to the rank of full professor with a salary of $4,000 to $6,000. A few men of long service and scientific eminence receive as much as $8,000 to $10,000. The material rewards of the mathematician are notably inferior to those of some of his university colleagues, in law, for example, in medicine, and in engineering, for these, in addition to their professorial salaries, often receive incomes, sometimes large incomes, from outside practice of their professions—professions whose service, though it is not superior to that rendered by the mathematician, is more obvious to the indiscriminating multitude, called the public. But the genuine devotee of science is not disheartened by the spectacle of such *iniquity*. He is content with such an income as enables him to support his family decently and to do the work to which he has been summoned by the inner call of his talents.

The life-work of the mathematician is richly compensated; but the compensations are not material—they are spiritual. One of them is the joy of life-long contact and intimate association with

the eager minds of the young. Another is life-long companionship with men devoted to science and other fields of scholarship. Another is the privilege of long summer vacations affording special opportunities for study, research, writing and travel. The mathematician's subject is an honored one and his life is a life of perpetual contact with fundamental thought. He knows that his science is the science of eternal verities and that its service is essential alike to the prosperous conduct of ordinary human affairs, to the advancement of science and to the support and progress of civilization. And, though he can not gain material wealth, his work, if he be a man of genius, may bring him fame—"the lofty lucre of renown."

CONSERVATION AD ABSURDUM

By Professor FRANK A. WAUGH
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THE constitution of the State of New York explicitly and absurdly provides that "the forest preserve . . . and the timber thereon shall not be sold, removed or destroyed." This is such a picturesque example of a good idea gone wrong that it ought to be framed and hung in all schoolrooms for pupils to study.

The good idea which went wrong was formerly very popular in those same schoolrooms. Boys and girls who spoke pieces on Fridays often recited "Woodman, spare that tree!" The woodman very seldom heard or heeded, but the idea, in other company, was growing and fructifying into the early doctrine of conservation. One great trouble of the present is that there are millions of honest citizens who have taken only the first degree in conservation, a degree in which the password is still, "Woodman, spare that chestnut."

Meanwhile the conservation lodge has grown in adherents and progressed in its ideas. George Pope Morris with his old password could not now get beyond the outer gate. Modern conservation was chartered and constitutioned by Theodore Roosevelt and Gifford Pinchot, and while the very first article in their constitution called for the preservation of American forests, the whole argument was pro-woodman, not anti-woodman. It was clearly recognized that in a civilized land the ax was the natural destiny of the forest.

To put the matter differently and better, it was proclaimed that conservation was not an end but a means. The end is utilization for the benefit of humanity. All nature's gifts—forests, fish, soil, human life—should be cherished, cultivated, protected and *used*. The fullest and highest use can be reached only after judicious saving and careful cultivation have made the most of each resource; and then the state is under obligation to transmit all these resources undiminished to posterity.

Every one of our natural resources comes under the laws of conservation. These laws may be codified in five principal chapters, *viz*:

1. **Saving**
2. **Cultivation**
3. **Improvement**
4. **Perpetuation**
5. **Utilization**

Apply these laws to the forests just for illustration.

First, the forest lands must be saved. They have to be rescued sometimes from the ungodly woodman admonished in Mr. Morris's poem; but oftener they have to be saved from fire. The great problem of forest conservation, especially in America, is fire protection. In other cases, too, our American forests had to be saved from over-grazing.

Second comes cultivation. The forest is a crop and requires attention like a crop of potatoes, except that different methods are used. Here we have the whole science and technic of sylviculture, one of the main branches of forest practice as taught in all the schools.

Thirdly, the forests ought to be improved. Good timber stands should succeed cut-over and waste areas; better species should follow poorer. Just as the farmer strives always toward crop improvement and just as the cattleman is forever trying to breed better stock, so the forester is not satisfied to cultivate his current crop but must always be seeking something better.

Fourthly, stands the vital problem of perpetuation. No forest will stand forever. Even the big sequoias will die some time. Our greatest worry over the millions of acres of cut-over, burnt-over land in America is not that the standing timber is gone but that no provision is made for a renewal of the forest. The great and favorite sin of our generation consists in robbing future generations. We use what should belong to them and we make no provision to replace what we steal.

Lastly and most importantly comes utilization. There is absolutely no sense in saving forests if they are of no use. Here is where the public mind needs a lot of clarification.

Of course any forest in being has some use, perhaps highly valuable uses. It protects a city's water supply or it offers recreation to millions. It is by no means necessary to chop down all the trees in order to use a forest.

On the other hand, it is equally unnecessary to leave every tree to die and rot on the ground. The simplest and best procedure is to remove each tree when it is mature. Under good management its place will then be taken by a younger tree, and so, by this system, the forest is always made up of young vigorous growing trees, whereas by the other system, required under the constitution of the state of New York, the forest must always contain a considerable percentage of decrepit, diseased, shattered, dead and rotting members. These dead, down and rotting trees add nothing to the beauty of the woodland. If the human soul really delighted in such forestry then would we make our parks on that formula and our home

A TRAIL ON MT. TOBY, MASSACHUSETTS AGRICULTURAL COLLEGE DEMONSTRATION FOREST

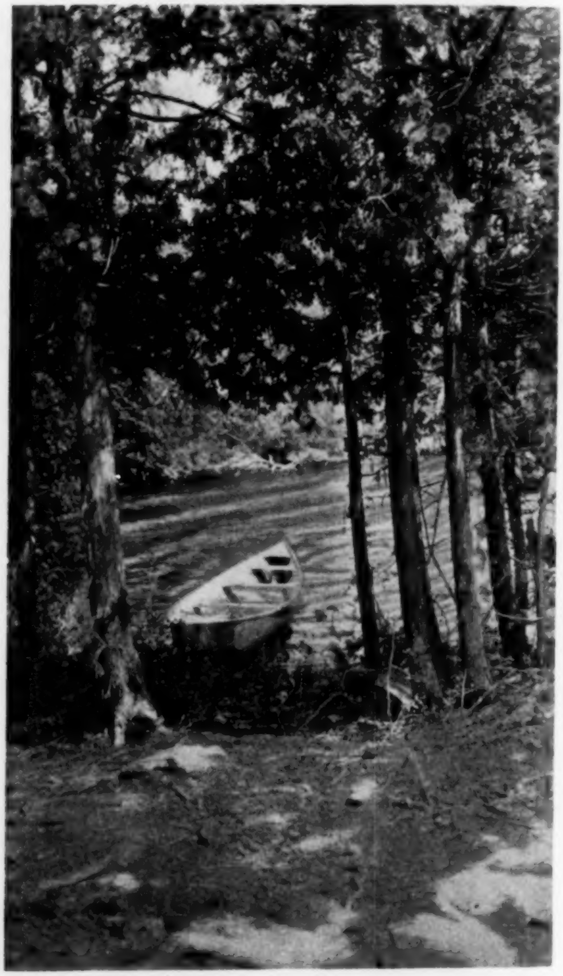
grounds would be embellished with blasted and decaying specimens. This dead and down material also increases the fire hazard. From every standpoint, in short, it is a detriment to the forest and useless to mankind. Yet that is what the constitution calls for.

Once the absurdity of this idea is seen it readily follows that when mature trees are removed for the good of the forest the lumber may be turned to human use without further injury to the sacred cause of conservation. In short there may be established a system of forestry in which woodlands are saved, cultivated, improved and perpetuated while the timber is also used—all of it. This is so simple that it hardly required to be stated. At least it would not, except for the contrary doctrine laughing at us in the Constitution, Art. VII, Sec. 7.

Wild as it is, this conflict of ideas is easily explained. It arose from the confusion in the public mind of American lumbering with scientific forestry. American methods of exploitation have of course devastated millions on millions of acres of fair and noble woodland with seldom a thought to any future. And so Mr. Morris, who wrote the poem, and Messrs. New York State and Co., who wrote the constitution, got the idea that forestry was all like that. They wanted "conservation with teeth in it." They were determined that the woodman should spare that tree, even if it did have to rot on the land. Mr. Morris said so with poetry; but the constitutional convention missed both the rhyme and the underlying facts.

Yet one should not rail too roundly upon the constitution nor the men who made it. There are millions of men and women with equal qualifications of ignorance who have never yet been elected to the legislature nor to a constitutional convention, but who in their more influential positions as presidents of woman's clubs, parish priests, family doctors, principals of schools and trolley car conductors, are spreading the same preposterous notion of conservation. One meets it everywhere. The foresters in charge of state and national forests probably hear from it oftenest and in its most horrendous form. For it is practically impossible for any one of them to order the cutting of 30 cords of stove wood from trees wrecked by an ice storm, or of 5 M F B M (as they say) of dimension lumber from mature forest stand, without entertaining immediately a stream of protests from outraged conservationists.

Not only does this conservation ad absurdum place an inhibition upon the cutting of timber, but the same patriotic protest rises against other forms of use, grazing, for example. Now it happens that nearly all forests include grazing lands. The herding of cattle, sheep, hogs, deer and other cattle on the forests has been prac-



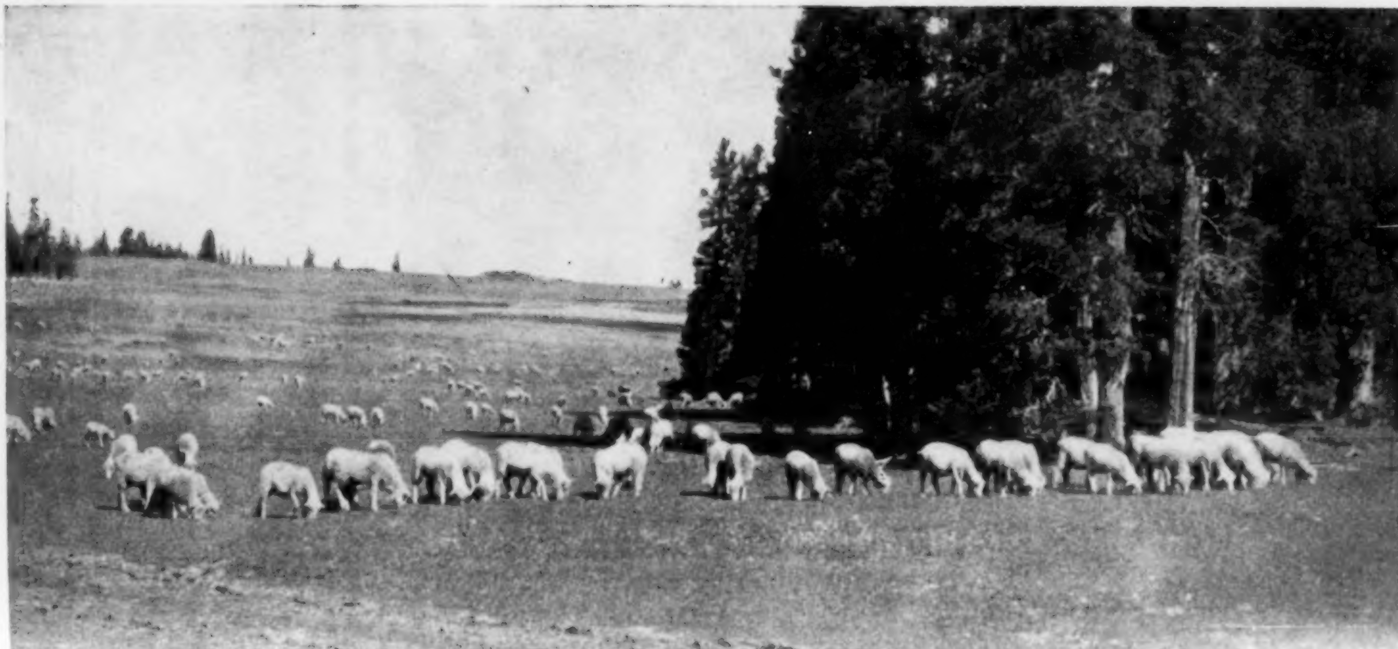
A CANADIAN LAKE—ONE OF MILLIONS

ticed from time unremembered—long before Columbus discovered America or Roosevelt discovered conservation. To-day the National Forests, to mention only one example, are grazed annually by about 14,000,000 cattle, sheep and horses. The meat, wool and leather produced are worth many millions of dollars. Yet with no less regularity than Old Faithful's eruption of steam and boiling suds comes the eruption of steamy alarm that the forests are being ruined by the sheep. Of course sheep can spoil a forest, and especially can they prevent the timely reproduction of a new stand of trees. At the same time it is wholly practicable to graze treeless

YOUNG WHITE PINE STAND IN A PRIVATELY OWNED MASSACHUSETTS FOREST

areas within forest boundaries (there are many such areas, some of them of considerable extent); and it is also perfectly possible to graze good woodlands at certain times and seasons without the slightest injury to growing timber.

In English, French and German forests, long famous for good administration, the commercial production of wild game is an established practice. Considerable numbers of deer, especially, are raised and slaughtered for food just as simply as beef is raised in Missouri and dressed in Kansas City. It would be entirely feasible to adopt a similar practice in American forests; but one shudders to think of the personal abuse which would descend upon any officer who would sanction the killing of "those beautiful deer" (which, by the way, the most violent protestants have never seen). There is at least one forest in America now which is over-stocked with

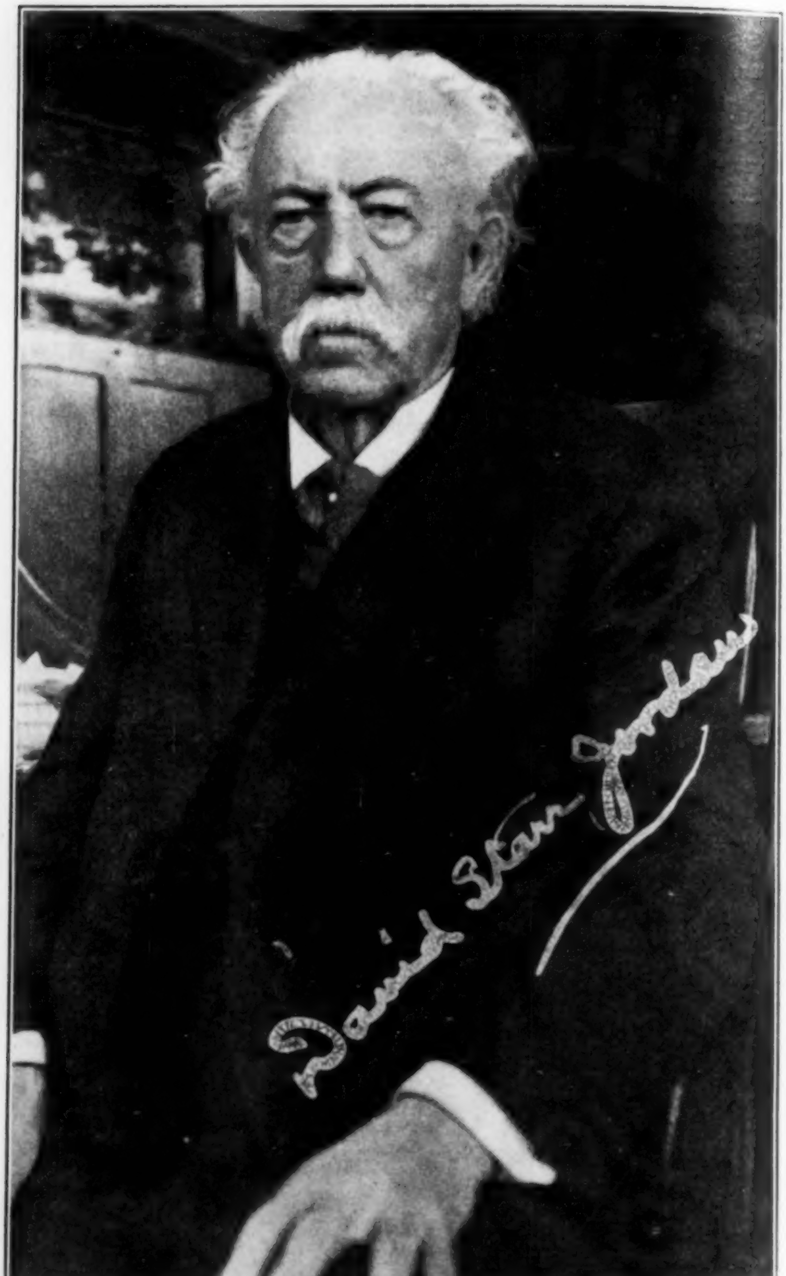


FINE RAMBOUILLET SHEEP GRAZING IN THE DIXIE NATIONAL FOREST, SOUTHERN UTAH

deer, where the numbers might be reduced to the benefit of the animals themselves, and where the older members are dying as naturally and as uselessly (anthropocentrically speaking) as the senile trees which shelter them. But what would be said by all those useful societies for the conservation of wild life if two thirds of the mature bucks in this herd were put on the market by the meat packers along with the beef and mutton which now pastures the same ranges? Such a step would be altogether rational, but it wouldn't get an encore from our conservation audiences.

Indeed there seems to be a sort of prejudice against all forms of practical use. The forest, it would appear, is to be reserved for esthetic enjoyment. While this is precisely the particular forest use in which I am personally most interested, and which I firmly believe ranks above all other uses, yet it is foolish to prohibit other uses, especially when they do not in the slightest interfere with our pet "higher uses." Perhaps our conservationists in excelsis et extremis will some day discover that water is one of the leading commercial products of the forests, that enormous quantities of it are being used through the week to turn machinery and on Saturday nights for baths and all day long for drinking purposes. When they learn of this commercial degradation of the forests they should, to be consistent, prohibit the removal of water from "the lands of the state, now owned or hereafter acquired constituting the forest preserve," as it says in the Constitution, Art. VII, Sec. 7 *ibid.* This prohibition of drinking water would be more popular in certain select circles than other constitutional provisions now in force, and it would be just as good conservation as some which now stands in the schoolbooks and the library books and the statute books.

What we really want is "conservation with teeth in it"; also with backbone enough to stand upright, with legs enough to travel on and with brains enough to know where it is going.



—Recently photographed by Julian P. Scott

DR. DAVID STARR JORDAN

Dr. Jordan, chancellor emeritus of Stanford University, was elected president of the Pacific Division of the American Association for the Advancement of Science at the recent Los Angeles meeting. Dr. Jordan was president of the American Association in 1909.

THE PROGRESS OF SCIENCE

By Dr. EDWIN E. SLOSSON
SCIENCE SERVICE, WASHINGTON

OUR UNEASY EARTH

WHENEVER a shake-up like that in Japan occurs we take thought of our underpinning. Is this solid earth so solid as it seems? Is not the crust likely to cave in any time, and if so what sort of a furnace shall we fall into? Will the earth open her mouth and swallow us up and our houses and our goods and close in upon us as it did upon the men of Korah who ventured to oppose Moses?

Such fears we may well have felt in our youth when we were taught that the earth was a molten mass held in by a thin solid crust. As the hot kernel of the earth cooled it would naturally shrink away from the outer shell, leaving it unsupported like the ice bridge over a dwindling stream. No, that is a highly inappropriate simile, let me say rather like an ill-baked cake. Perhaps the basaltic dough out of which our world was molded might not have been mixed right and might collapse in the cooling with disastrous results to us animalculae who dwell upon its upper crust.

Also we used to be told that this shrinkage of the earth caused a crumbling of the crust into mountain ranges, and the professor of geology showed us just how it was done by rumpling up the table cloth or the pages of his manuscript by shoving his hands together from both sides. We therefore lived in dread lest a new Himalaya might arise at any moment in our midst and catch us on its peak or slippery slope.

But better knowledge of the composition and character of the materials that form our globe has given new ideas of its interior and new theories of its mountain formation and earthquakes. It is now held that the earth is as rigid as steel to sudden shocks and as plastic as putty to long continued pressure. Don't say that is an impossible combination of qualities, for you can easily prove that it is not. If you give a sharp tap to an ordinary phonograph record you will knock a piece out of it. On the other hand, if you lay it on an uneven surface and pile books on it you know that the disk gradually warps out of shape and gives awful music. So the earth, behaving like a rigid body, will crack under a local strain and transmit the vibrations of it swiftly to all parts of the world and yet the continents float upon its plastic mass so stably that their rise and fall is imperceptible. The pressure is so great at a depth of some sixty miles that the rock will flow and therefore each section of crust sinks to its proper level and remains in perpetual balance with all the rest of it.

This is known as the "isostasy" theory and has been chiefly worked out by Hayford and Bowie of the U. S. Coast and Geodetic Survey. According to them mountains are not formed by crumbling but by swelling. As the mountains are worn away through erosion by wind and water, the sediment carried down by the rivers is deposited on the edge of the sea. This transfer of material from the mountains to the sea above ground is compensated underground by the slipping of an equivalent amount of the hot viscous material to the base of the mountain so that the mass of the mountain area and of the ocean area remain the same. Mountains may therefore be pushed up from below as they are being rubbed off on top. But

not at the same rate, for the material forced into the crust from below a mountain area is denser than that eroded from the surface, hence the mountain area will be gradually worn down to a low elevation. So the material of the rocky crust of the earth contracts and expands, rises and falls, erodes and deposits. We find ocean fossils on top of the mountains and some parts of a continent may have submerged and emerged repeatedly in the course of time. Where the mountains are old and worn down and the land has been leveled, there is little likelihood of earthquakes, for the crust has practically reached equilibrium. But where the mountains are young and rise sharply from the sea there are still adjustments to be made and these cause slips and jerks comparatively slight in amount but sufficient to bring disaster upon the puny works of man.

A PSYCHOLOGIST UNDERTAKES TO EDUCATE CHIMPANZEES

ALREADY the revival of the controversy about man's origin by "special creation" or by "evolution" has given a new impetus to research. Dr. Robert M. Yerkes, psychologist and student of animal behavior, has undertaken an intensive study of the chimpanzee, one of the man-like apes. There are only three kinds of great ape, the gorilla, the chimpanzee and the orang-utan. Of these the chimpanzee is perhaps most like man in its behavior.

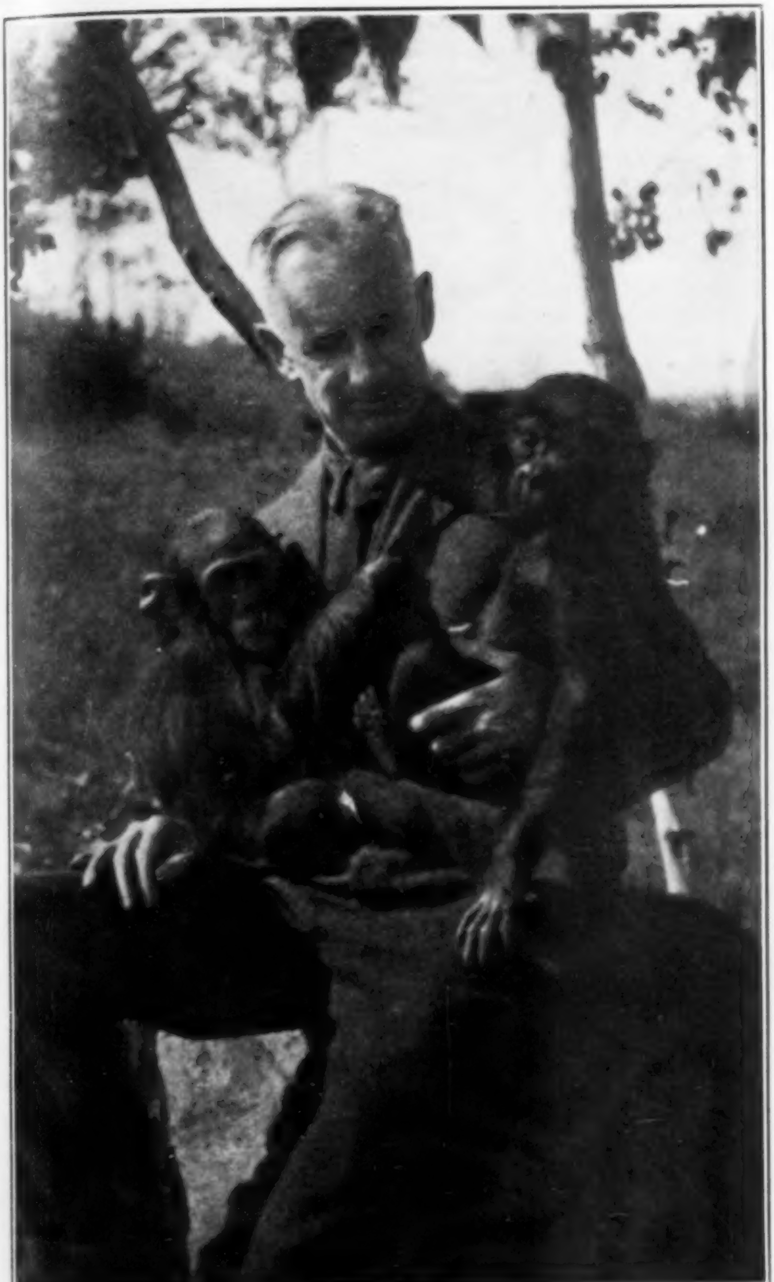
Dr. Yerkes's pair of young chimpanzees were brought to him from Africa. It is reported that he originally named them Adam and Eve and called their garden home Eden! But more recent account has it that "sense" vanquished "sentiment" and the animals are now known as "Chim" and "Panzee." Thus, doubtless, the scientist hopes to avoid wounding the sensibilities of Adams and Eves of the genus homo and increasing prejudice against the anthropoid apes in those who consider evolution antireligious.

Chim is a little "blackface" chimpanzee from the Belgian Congo. He is thought to be about 14 months old and he weighs about 20 pounds. Dr. Yerkes says it would take a lively child of three to keep up with him at play or in solving problems which depend on manual skill and dexterity. Panzee—a name peculiarly appropriate to the female of the species—is a "whiteface" from British West Africa. She is somewhat larger than Chim, but weighs less, although she is thought to be about 18 months old.

The chimpanzee couple will winter in Washington, where Dr. Yerkes plans to seek answers to such questions as: Can the chimpanzee be taught to speak? Already he knows that it can understand much that is said to it. Has it ideas and can it solve practical problems in novel and original ways? Does it of its own initiative use objects as tools? The doctor says Chim acts more "intelligently" and "reflectively" than a child of his age. To what extent is the chimpanzee educable? Can it acquire scores or hundreds of habits, if trained systematically as is the child?

Dr. Yerkes has had a great deal of experience in educating animals of all grades from earthworms to college students. He succeeded in training earthworms to find their way out of a maze so thoroughly that they would retain their training even after their heads were cut off. This experiment was not tried on college students. But I should be willing to wager that the chimpanzee will not learn as much from him as he will from them.

Man's superiority over all other creatures of earth, water and air seemingly is due to intelligence. Careful, skillful, long-continued study of the growth and development of the chimpanzee, and especially of its intelli-



Dr. Yerkes with "Chim" and "Panzee"

gence and its emotions may throw invaluable light on the nature and development of mind in general. This certainly would be worth while, for mind surely is the most fascinating aspect of Nature.

The task which Dr. Yerkes has set himself is as difficult as it is important, for the great apes, to be reared successfully and kept in good health and spirits, must be treated much as children. Little is known with certainty about the habits, life history and mental life of any of the apes. This is chiefly because of the discouraging difficulties in obtaining, keeping and studying them. But why journey to darkest Africa—or for that matter lightest Africa—to study the nest-building instinct (or is it tradition) of the chimpanzee when you can see a tree-nest built by one of these ridiculously and pathetically man-like animals in your own back yard!

Reports of Dr. Yerkes's discoveries in the realm of ape mind will be eagerly and impatiently awaited by those who consider the chimpanzee to be man's cousin as well as by those who deny their relationship to him.

THE FAITH OF THE SCIENTIST

The things we are surest about we do not talk about. We do not have to. There are certain things that all sensible men take for granted and there is no use in trying to convince those who are not sensible. But once in a while it is well to dig down to the very foundations of our faith to see what they are.

There is one principle that underlies all the sciences as it does all ordinary life and yet is not often specifically pointed out.

This is the invariance of nature or the constancy of cause and effect. That under the same circumstances the same thing will happen always anywhere. This is a bit vague, for of course the circumstances are never twice the same all through the universe. And nobody can prove it or tell why it must be so.

For instance, who knows if the law of gravitation will hold true tomorrow? Why should not all particles of matter repel one another instead of attracting one another?

Suppose some erratic oak tree, in a desire to be original, should begin to bear watermelons instead of acorns? Who is entitled to tell it that it can not? Suppose the earth should get tired of always turning the same way and take a notion to turn from east to west for a change? How do you know it won't? You don't know. Yet you are sure it won't.

The only reason you can give is that this never has happened, but that is merely the prejudice of the conservative, the negation of all progress.

Yet this principle, that like causes always produce like effects, has to be assumed by pure faith before we can undertake our next day's work. It is also a necessary assumption in all scientific calculations. Let us consider, for instance, the astronomer, for he indulges in longer term prophecies with greater assurance and success than any other scientist. The point is best put by a French poet, Sully-Prudhomme, in a beautiful sonnet that may be translated as follows:

The Rendezvous

By Sully-Prudhomme

'Tis late; the astronomer his vigil stern
On lofty tower prolongs. In silent space
He seeks his golden isles, nor turns his face
Till the starry host grows pale with morn's return.
Bright worlds, as grain the winnowing flail doth spurn,

MEMORIAL TO A METEORITE

Situated near Wold Newton Hall, East Yorkshire, England. The slab bears the following inscription: On this spot, Dec. 13th, 1795, fell from the atmosphere an extraordinary stone. In breadth—28 inches, in length—30 inches, and whole weight—56 lbs. This column, in memory of it, was erected by Edward Topham 1799.

Fly past thick-clustering nebulae a-light;
His eager gaze one streaming orb pursues in flight,
He calls: "This hour, ten centuries hence, return."
Return it shall. Nor time nor space abates,
The Everlasting Fact it never can assail.
Men pass from view; Eternal Science waits.
An though Humanity itself should fail,
Fair Truth will stand, alone, upon the tower
To keep that tryst at the appointed hour.
(Translated by F. P. H.)

Now I fancy that Sully-Prudhomme with poetic license has exaggerated a bit the marvelous power of prescience possessed by the astronomer. To fix the exact hour for a comet's return a thousand years in advance is rather closer figuring than we can do with certainty. There is always the possibility that the comet may be wrecked in a collision or sidetracked by some star.

But Sully-Prudhomme does not exaggerate the confidence of the scientist in his fundamental principle of the constancy of natural law. The astronomer is willing to stake his life, or what he values more, his scientific reputation, that if none of these accidents happen and if he has rightly weighed all the factors involved, the result will be exactly as he says. He is so sure of it that if a comet does not return on an expected date he will be confident that some unforeseen force has intervened and he will set about to find it. If he does not find out what is wrong, other astronomers will take up the task and devote their lives to finding the cause of the discrepancy. They may keep at the problem for a thousand years and never think of saying: "Well, perhaps there isn't any reason. Comets are queer things any way."

And if an oak tree should take to bearing watermelons—things almost as unexpected have happened—the botanists would be absolutely positive there was something new inside or outside the tree that set it to acting so. They would start to experimenting and probably find out what it was in the course of time. "There's a reason" is the faith of the scientist and so far he has never been belied.